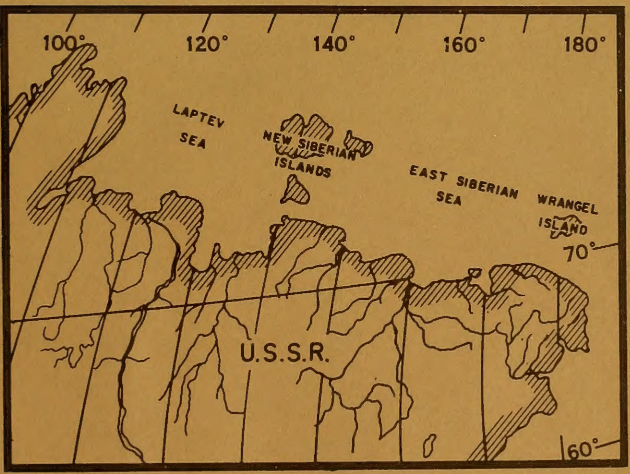
TR-200

TECHNICAL REPORT

SOME SUMMER OCEANOGRAPHIC FEATURES OF THE LAPTEV AND EAST SIBERIAN SEAS



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ABSTRACT

In August-September 1963, a high degree of stratification for both temperature and salinity was observed in the Laptev and East Siberian Seas. Temperatures decreased with depth and with distance away from the Siberian coast, and salinities decreased vertically from the bottom and toward the coast.

The five large rivers emptying into the Laptev Sea influence the temperature-salinity characteristics to a great extent causing high temperatures and low salinities near the coast and in the upper layers seaward. The Lena River fluvial plume, on the basis of salinity distribution, was observed to extend in a north to northeasterly direction from the river delta. The combined effects of the Khatanga and Anabar River runoff extended in a northeasterly direction from the Khatanga River Estuary with vertical distribution of the low salinity water limited to the upper 10 meters.

Water of three temperature-salinity relationships was observed in the East Siberian Sea in both 1963 and 1964. Near the coast, between the Indigirka River and Chaunskaya Bay, warm low salinity water was observed. In the sea's shallower western regions, cold water with slightly higher salinities was noted. Both these water types can be attributed to river runoff with cooling and mixing in transit accounting for the colder water and higher salinities. Water in the eastern East Siberian Sea through Long Strait and

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FOREWORD

The Laptev and East Siberian Seas, characterized by an average depth of less than 100 meters and being the recipients of large quantities of fresh river water, offer unique environmental conditions for oceanographic study. This report is a study of summer oceanographic features in the two seas as observed in 1963 and 1964. It deals mainly with the water characteristics affected by the effluent of the seven large rivers emptying into these seas.

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Captain, U.S. Navy
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I. INTRODUCTION

Two surveys were conducted in the East Siberian and Laptev Seas, one during 1963 and the other during 1964 to study summer oceanographic conditions.

The Laptev and East Siberian Seas lie north of Siberia over the broad, shallow continental shelf on the periphery of the Arctic Basin (Fig. 1). They represent two of the marginal seas formed in the division of the north Siberian continental shelf by peninsulas and islands.

Both seas are characterized by average depths of less than 100 meters (330 feet) and, as a consequence, large surface areas in relation to their total volumes. The combined runoff of Siberian rivers received by these seas and the seas' large surface to volume ratios make them effective in influencing surface water conditions in the Arctic Basin (Sater, 1963).

Ice coverage is typical of the East Siberian and Laptev Seas during most of the year. Open water may be found in the northern regions of both seas during the summer, but the principal ice-free area is near the Siberian coast. A wedge-shaped region of open water, beginning west of the New Siberian Island group and narrowing eastward toward Wrangel Island, is a usual summer feature. This large ice-free area is most likely the result of river outflow from the Siberian mainland (Zubov, 1963).

Seven large rivers add relatively high temperature, fresh water to the two seas.

II. NARRATIVE OF OPERATIONS

The first of the two surveys was conducted in August-September 1963 by USCGC NORTHWIND (W-AGB 282) in cooperation with the Naval Oceanographic Office (NAVOCEANO). During this operation, 180 oceanographic stations were occupied over a period of 33 days in the western Chukchi, East Siberian, and Laptev Seas (Figs. 2 and 3). The second survey was conducted in August-September 1964 by USS BURTON ISLAND (AGB 1) also in cooperation with NAVOCEANO. During this operation, 74 oceanographic stations were occupied over a period of 76 days in the East Siberian Sea with 62 of the stations occupied in the last month (Fig. 4). Stations 13 through 17 were occupied in the Chukchi Sea and are not included in Figure 4.

Scientific personnel aboard NORTHWIND included seven NAVOCEANO personnel, one undergraduate and two graduate students from the University of Washington, one graduate student from the University of Southern California, and one Weather Bureau representative. The scientific party aboard BURTON ISLAND consisted of seven NAVOCEANO representatives and two University of Washington graduate students.

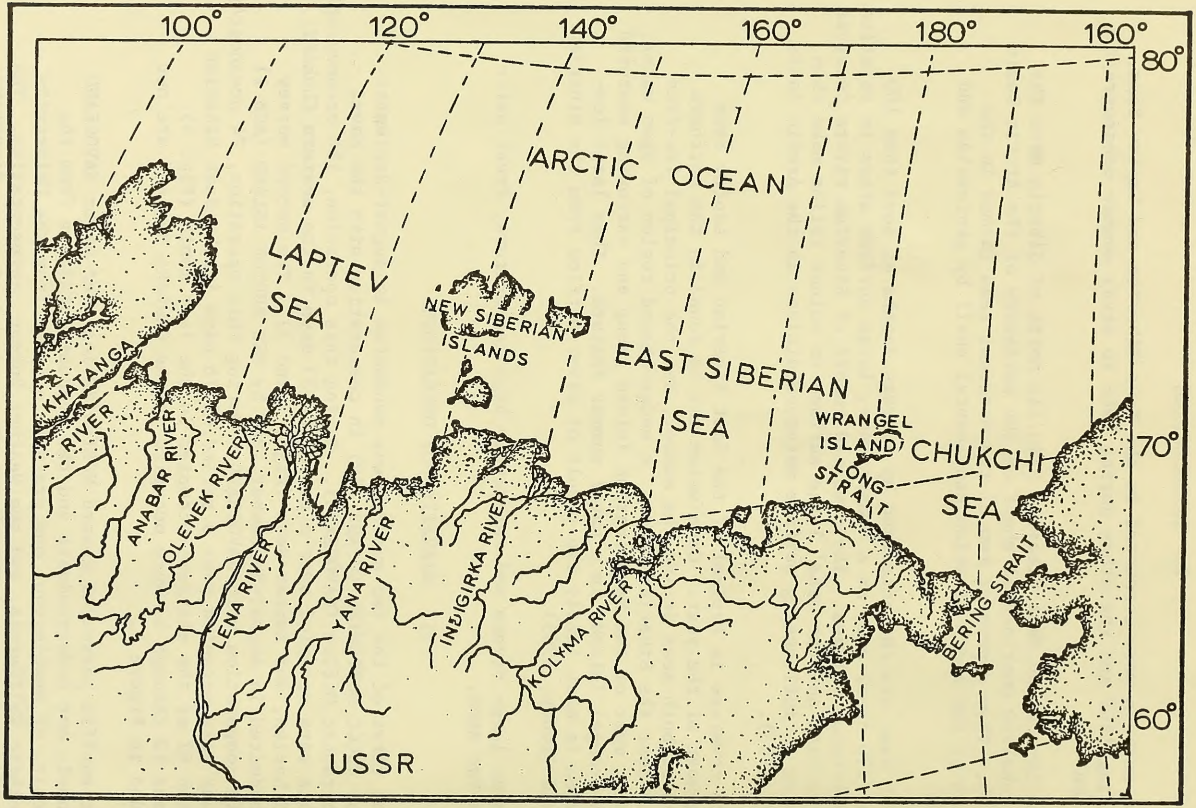


Figure 1. Van der Grinten projection of the Laptev and East Siberian Seas.

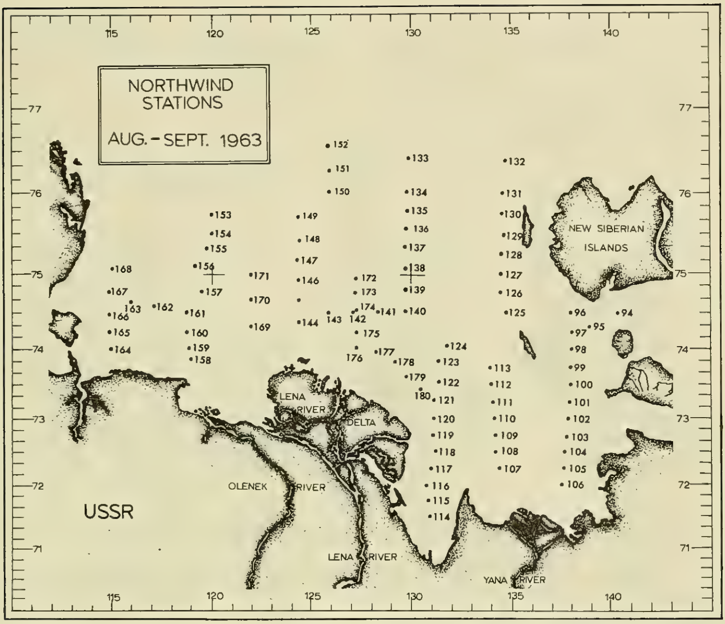


Figure 2. Oceanographic stations occupied in the Laptev Sea during the 1963 NORTHWIND cruise. Stations are numbered consecutively in order of station occupation.

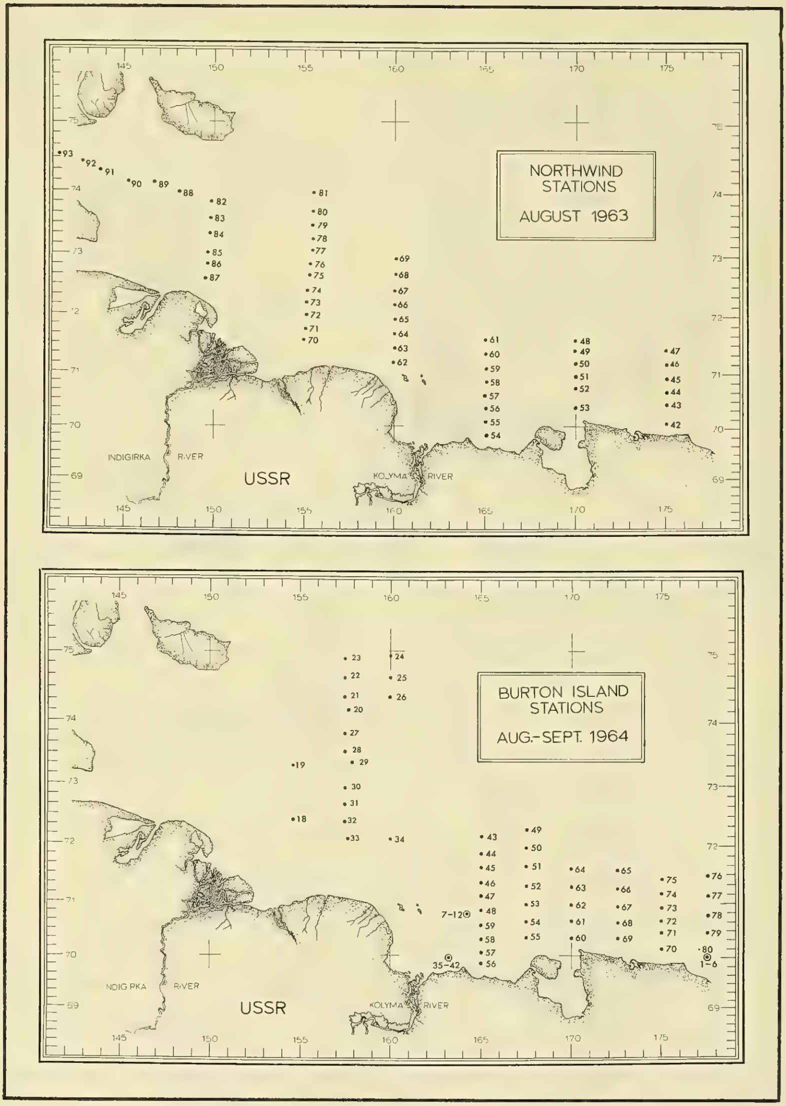
All oceanographic station occupation, chemical analysis, and shipboard data reduction were accomplished by NAVOCEANO and University of Washington personnel with supporting assistance from officers and crew members of both ships.

III. METHODS AND PROCEDURES

A. Sampling Techniques.

Serial-depth Nansen cast observations were made from surface to bottom at all stations occupied in an attempt to obtain representative samples throughout the water column. A single cast was considered adequate for providing coverage at all stations.

Water depths, typically less than 50 meters (164 feet), precluded the use of unprotected reversing thermometers for determining themometric depth values. A satisfactory approximation of sampling depth was obtained using the cosine of the wire angle multiplied by the amount of wire out. This simple method was feasible because of the very shallow water involved, the low wire angles encountered, and the close observation maintained on the meter wheel.



Figures 3 and 4. Oceanographic stations occupied in the East Siberian Sea during the 1963 NORTHWIND and 1964 BURTON ISLAND cruises. All oceanographic stations are numbered consecutively in order of station occupation. BURTON ISLAND oceanographic stations indicated by a circle and hyphenated numbers represent multiple-cast anchor stations. NORTHWIND stations 1 through 41 in 1963 were occupied in the Chukchi Sea and are not discussed in this report.

1. Oceanographic Samples. Tin-lined Nansen bottles equipped with paired, protected reversing thermometers were used for collecting water samples and temperature data. Thermometers were allowed to stabilize in an enclosed space for 15 minutes prior to being read. While the thermometers were stabilizing, sample fractions were drawn for dissolved oxygen, salinity, pH, and dissolved inorganic phosphate determinations. Samples also were drawn to be frozen for subsequent micro-nutrient analyses and, aboard BURTON ISLAND only, turbidity analyses.

2. Geologic Samples. Bottom sediment samples were obtained using Kullenberg gravity corers with 6-foot long, 2-inch diameter barrels, Phleger corers with 4-foot long, 1.5-inch barrels, and orange peel bucket samplers equipped with canvas anti-wash skirts. All sediment samples obtained were sent to the University of Washington oceanographic laboratory for analyses.

3. Current Observations. Current observations were made aboard BURTON ISLAND using a deck readout Hydro Products current meter and Gemware and Ekman mechanical current meters. The meters were suspended from the ship's bathythermograph boom.

Although four current stations each of over 25 hours duration were occupied, much of the data are subject to question. Because BURTON ISLAND had only a bow anchor, erroneous readings probably were introduced by the play of the ship about the anchor cable. Functional difficulties were experienced with the meters because of ice conditions and low ambient air temperatures.

B. Analytical Methods.

Determination of salinity, dissolved oxygen, pH, dissolved inorganic phosphate, and turbidity were made aboard ship. Additional water samples were frozen for later analyses of dissolved silicates and nitrates by laboratories ashore. The frozen samples from NORTHWIND were analyzed at the chemical laboratory of the University of Washington and those from BURTON ISLAND were analyzed at the NAVOCEANO chemical laboratory.

1. Salinity Determination. Salinity determinations were made aboard ship using an Industrial Instruments inductively coupled salinometer. Water samples were allowed to come to room temperature before analyses were run, but in no case were salinity samples allowed to stand for more than 72 hours before analysis. Sample evaporation was minimized by drawing and storing samples in glass stoppered citrate bottles with rubber gaskets.

2. Dissolved Oxygen Determination. Dissolved oxygen was determined using the NAVOCEANO modification of the Swinnerton-Linnenbom-Cheek (1962) gas chromatographic method. On both cruises, a Fisher gas

partitioner equipped with a Texas Instruments integrating recorder was used. All dissolved oxygen samples were run immediately upon being drawn. This was done in an attempt to minimize changes in oxygen tension owing to sample temperature elevation.

3. pH Determination. pH determinations were made using a Beckman model 76 expanded scale pH meter. Water samples were placed in a temperature bath and allowed to come to room temperature before analysis.

4. Dissolved Inorganic Phosphate Determination. Dissolved inorganic phosphate determinations were made using the ascorbic acid reduction method of Murphy and Riley (1962). A Beckman model DU spectrophotometer with a 10-centimeter path length cell was used for these analyses. The excessive amount of particulate matter encountered in the water made it necessary to run turbidity blanks for each sample.

5. Turbidity Determination. Sea water turbidity was measured for the Naval Research Laboratory aboard BURTON ISLAND using a Helige model 800 turbidimeter. Samples were placed in a temperature bath, allowed to come to room temperature, and then manually shaken before measurements were made. Care was taken to eliminate errors introduced by bubble formation in the sample.

C. Disposition of Data.

The Nansen cast data were forwarded to the National Oceanographic Data Center (NODC) for computer processing. NODC reference numbers assigned were 31188 for NORTHWIND and 31428 for BURTON ISLAND. IBM 7070 computations provided temperature, salinity, and dissolved oxygen interpolations at standard depths in addition to sigma-t, specific volume and dynamic depth anomalies, and sound velocity calculations from the observed data.

Turbidity data collected in 1964 were turned over to the Naval Research Laboratory for reduction and analyses.

Temperature, salinity, dissolved oxygen, inorganic phosphate, reactive silicate, and nitrate data collected on both cruises have been used in an M.S. thesis for the University of Washington by Louis A. Codispoti.

D. Units of Measurement.

Oceanographic parameters are reported in the English or metric units of measurement normal to the measuring instrument. For convenience, tables of equivalents are presented in appendix A for converting values from one system to the other.

IV. OCEANOGRAPHY

A. The Laptev Sea.

The temperature and salinity distribution observed in the Laptev Sea in 1963 revealed a high degree of stratification at the time of the survey. Temperatures generally were observed to increase toward the Siberian coast and vertically from the bottom, and salinities were observed to decrease toward the coast and vertically from the bottom. Figures 5 through 8 show horizontal temperature and salinity distribution in the upper 15 meters as observed in August and September 1963.

1. Temperature-Salinity Relationships. Water of two very general types was observed in the Laptev Sea during the NORTHWIND survey. Below 20 meters on most stations, temperatures and salinities were observed to be similar to surface water found in the Arctic Basin. In addition, on some of the northernmost stations, water with the same characteristics was observed throughout the water column. Water with temperatures and salinities similar to those found at the surface in the Arctic Basin will be referred to here as "Arctic Basin Surface Water". Temperatures of 1.4° to -1.8°C and salinities greater than 28‰ are characteristic of Arctic Basin Surface Water.

In the upper 15 meters at the remaining stations, temperatures were observed to be considerably higher and salinities considerably lower than those of Arctic Basin Surface Water. This high temperature, low salinity water will be referred to here as "Southern Laptev Water" as it originates in the southern Laptev Sea.

a. Arctic Basin Surface Water. It is reasonable that water in the northern Laptev Sea should have temperature and salinity characteristics similar to those in the surface waters of the Arctic Basin. Coachman and Barnes (1962) describe Eurasian Arctic Basin Water as being cold and relatively dilute in the upper 25 meters, with salinities ranging from 28.5 to 33.5 ‰ and temperatures always less than 0°C. Below 25 meters, the temperature is described as being at or near freezing and isothermal down to 50 or 100 meters, with an accompanying marked increase in salinity.

Temperatures observed in the northern Laptev Sea in 1963 ranged from less than -1.5°C at the surface to -1.8°C at 50 meters. Salinities ranged from 28.6 ‰ at the surface to 33.9 ‰ at 50 meters. Since these values fall within the range described by Coachman and Barnes, the water can be considered to represent Arctic Basin Surface Water. This water also was observed at 20 meters and below on most other stations, with temperatures generally less than -1.0°C and salinities generally greater than 28 ‰ .

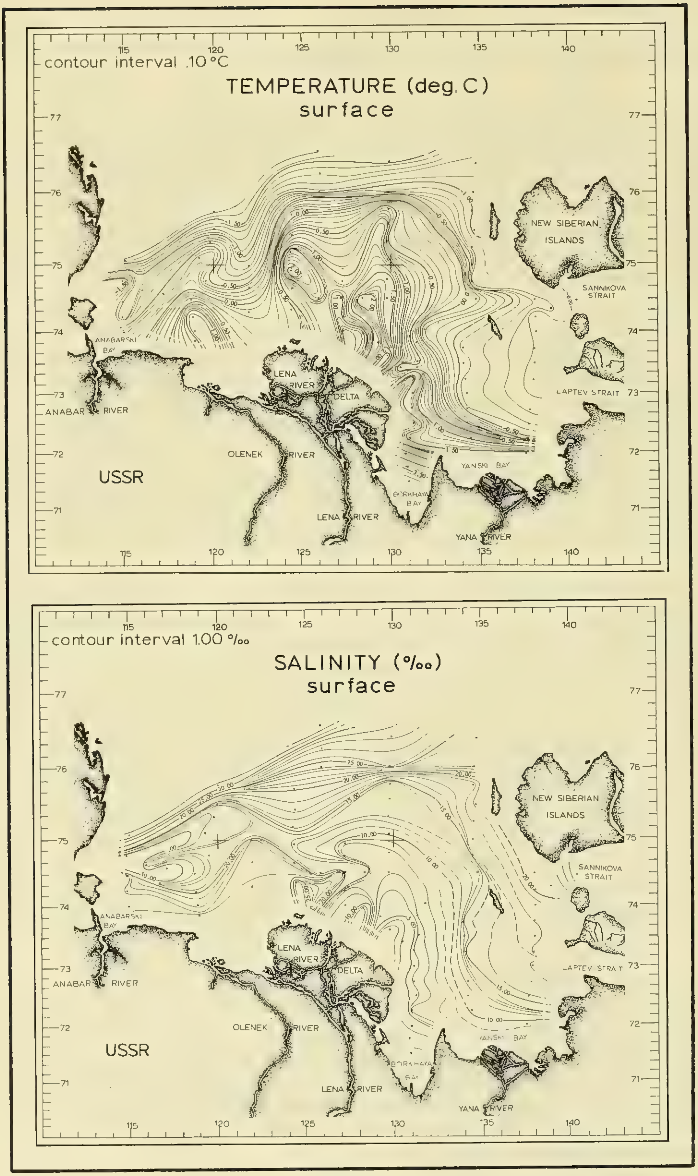


Figure 5. Observed surface temperature and salinity distribution in the Laptev Sea. All data represented are from the 1963 NORTHWIND survey.

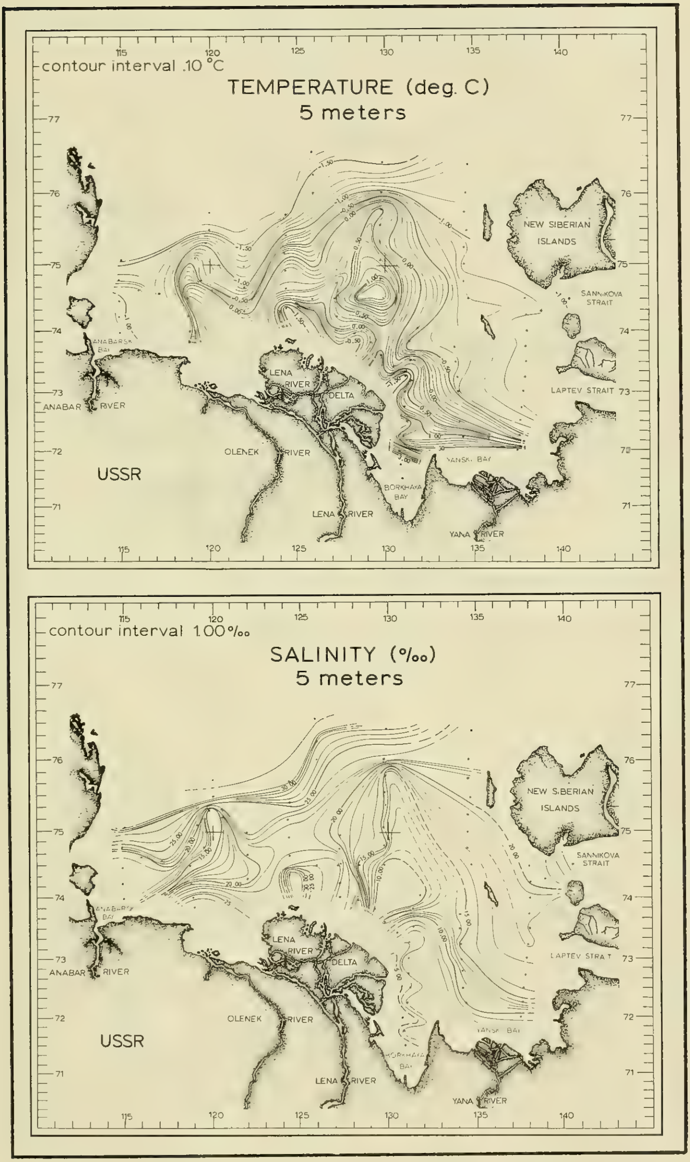


Figure 6. Observed 5 meter temperature and salinity distribution in the Laptev Sea. All data in this and the following two figures have come from the 1963 NORTHWIND survey.

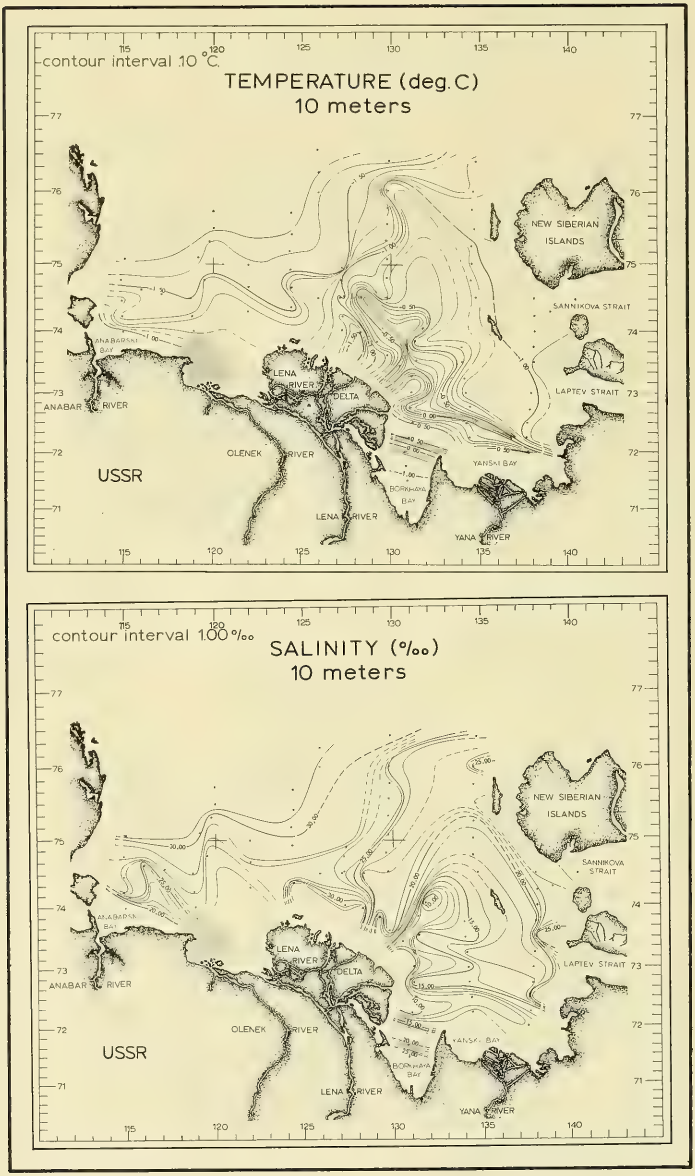


Figure 7. Observed 10 meter temperature and salinity distribution. Shaded areas are less than 10 meters deep.

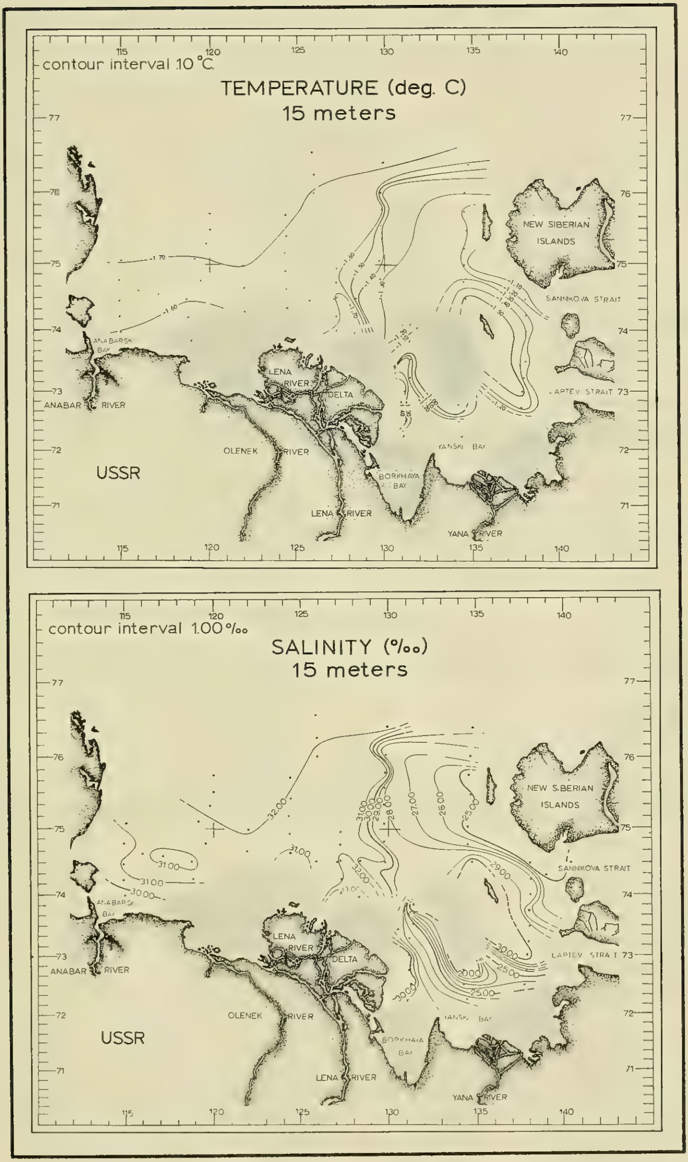


Figure 8. Observed 15 meter temperature and salinity distribution. Shaded areas are less than 15 meters deep.

b. Southern Laptev Water. The relatively high temperatures and low salinities observed in what has been termed "Southern Laptev Water" may be directly attributed to the large amounts of river runoff received by the southern Laptev Sea. According to river drainage figures given by L'vovich (see table I), the Lena, Yana, and Olenek Rivers contribute an average of 554 cubic kilometers of fresh water to the Laptev Sea yearly. In addition, the Khatanga and Anabar Rivers contributed sufficient fresh water to show a discernable plume in the upper 10 meters during the NORTHWIND survey although no annual runoff figures are cited in table I.

Table I. River drainage figures for the Siberian rivers draining into the Laptev and East Siberian Seas according to L'vovich (1953).

RIVER	LENGTH (KM)	DRAINAGE AREA (KM^2)	ANNUAL DISCHG (KM^3)
LENA	4270	2,425,000	488
YANA	879	244,700	31
INDIGIRKA	1790	360,400	57
KOLYMA	2400	644,100	120
OLENEK	2415	246,500	35
ANABAR	924	81,600	—
KHATANGA	779	346,100	—

Characteristic temperatures and salinities observed in Southern Laptev Water cover a broader range than those in Arctic Basin Surface Water. Temperatures encountered were from 0°C to over 3°C near some river mouths. Salinities observed ranged from 28‰ , the lower defined salinity limit for undiluted Arctic Basin Surface Water, to slightly over 2‰ .

2. Oceanographic Features. Three features of interest are evident in the southern Laptev Sea on the basis of observed temperature and salinity distribution. These are the Lena River fluvial plume, the combined Khatanga-Anabar fluvial plume, and the region of low temperatures and high salinities observed about 20 miles north of the Lena River Delta.

Some dilution effects are observable from the Olenek and Yana Rivers, but, generally speaking, station coverage was not adequate to develop the fluvial plume from either river. No attempt is made here to distinguish between effects of the Olenek River and the combined Khatanga and Anabar Rivers.

In addition to the oceanographic features noted, dissolved oxygen measurements indicated frequent oxygen supersaturation in both types of water discussed.

a. The Lena River Fluvial Plume. Definition of the Lena River plume using isotherms and isohalines is somewhat subjective, depending upon temperature and salinity values chosen. Surface temperatures in the plume ranged from 3.75°C near the river delta to -1.00°C where definition became poor. Similarly, surface salinities ranged from 2.56‰ near the river mouth to over 20‰ where the plume was less clearly defined. The 0° and -0.5°C isotherms and the 15 and 20‰ isohalines have been used here to overcome some of the subjectivity inherent in using a single temperature and salinity value for plume description.

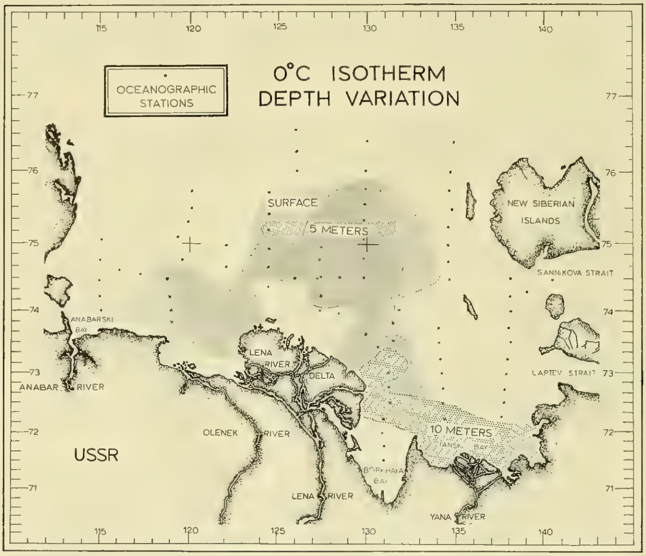
(1) Temperature Distribution. Observed temperatures indicate a roughly wedge-shaped distribution of Lena River water in the Laptev Sea during the 1963 survey. Both the 0° and -0.5°C isotherms suggest a northerly distribution of considerable areal extent at the surface and 5 meters, but the isotherms at 10 meters suggest a more localized, easterly distribution.

Figure 9 illustrates the relative locations of the 0°C isotherm at the surface, 5 meters, and 10 meters. The -0.5°C isotherm is shown for comparative purposes.

The surface 0°C isotherm encloses two regions of relatively high temperature water. The larger region, probably attributable primarily to the Lena River, occurred north and east of the Lena River Delta and in Borkhaya Bay. The smaller, probably a result of Olenek River outflow, occurred west of 123°E and north of the Olenek River mouth.

The same general regions of lesser areal extent and slightly lower temperatures are defined at 5 meters as shown in figure 9. At a depth of 10 meters, the 0°C isotherm defines a small region east of the Lena River Delta, the northern portion of Borkhaya Bay, and Yanski Bay. Below 10 meters this isotherm does not serve to describe the Lena River plume.

Surface and 5-meter definition, using the -0.5°C isotherm, approximates that obtained using the 0°C isotherm. At 10 meters, however, the -0.5°C isotherm describes a considerably larger region



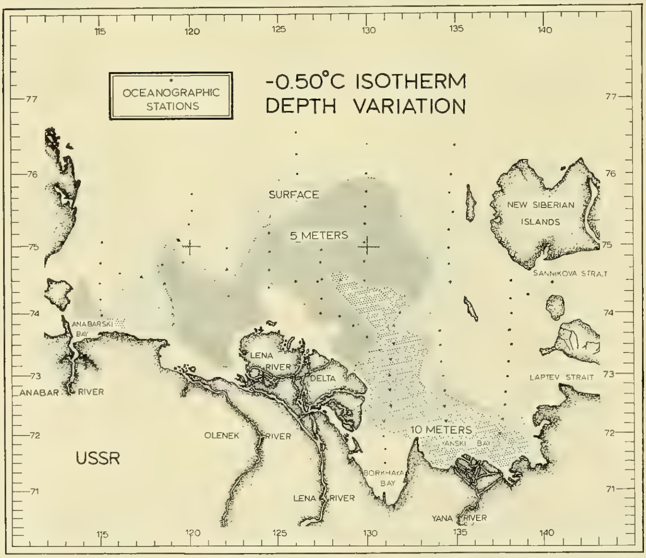


Figure 9. Definition of the Lena River plume at surface, 5, and 10 meter levels using the 0° and -0.5°C isotherms. Water temperatures are warmest near the river.

with greater northern extent than does the 0°C isotherm. The -0.5°C isotherm does not define the river plume below 10 meters. No temperature warmer than -0.77°C was observed at 15 meters although temperature effects from Lena River water were clearly observable as shown in figure 9.

(2) Salinity Distribution. Observed salinities suggest a wedge-like distribution of Lena River water in the Laptev Sea similar to that implied by observed temperature distribution. Interpreted configuration of 15 and 20 ‰ isohalines, however, indicates a slightly more easterly distribution at depths of 5 and 10 meters than indicated by observed temperatures.

The 20 ‰ isohaline variation presented in figure 10 illustrates its relative location at the surface and at depths of 5 and 10 meters. Relative locations of the 15 ‰ isohaline for the same depths are shown for comparative purposes.

Surface 20‰ isohalines illustrate only the combined effects of the Lena and Khatanga-Anabar River plumes. Surface definition of individual fluvial plumes is limited to salinity values less than 15 ‰ as illustrated in figure 10. The 20‰ isohaline extends to 76°00'N at the surface and at 5 meters and to around 75°20'N at 10 meters. At 15 meters, this isohaline existed only near 74°00'N and 132°00'E and did not serve to define the fluvial plume.

The 15 ‰ isohaline does not define the Lena River plume at the surface, but definition may be observed in the 13 ‰ isohaline configuration seen in figure 5.

At a depth of 5 meters, the 15 ‰ isohaline extends to the vicinity of 75°50'N and defines an elongated region of the same general shape but only approximately half the area defined by the 20 ‰ isohaline. The northern extent of the 15 ‰ isohaline at 10 meters is in the vicinity of 74°30'N, but the region defined appears primarily in the southernmost Laptev Sea. Below 10 meters, water with salinity less than 15 ‰ was noted only in a limited region near 74°00'N and 132°00'E. No water with salinity less than 29‰ was observed below the 20-meter level in the Laptev Sea.

(3) River Effluent Distribution. Budinger, Coachman, and Barnes (1964) point out that the horizontal distribution of effluent water in the open sea appears to be governed by a combination of offshore circulation and local prevailing winds. Both of these factors probably are effective in governing distribution of effluent water in the Laptev Sea, but their relative importance is unclear. Because the Laptev Sea is comparatively shallow, surface winds probably assume an important role in distributing this low density water.

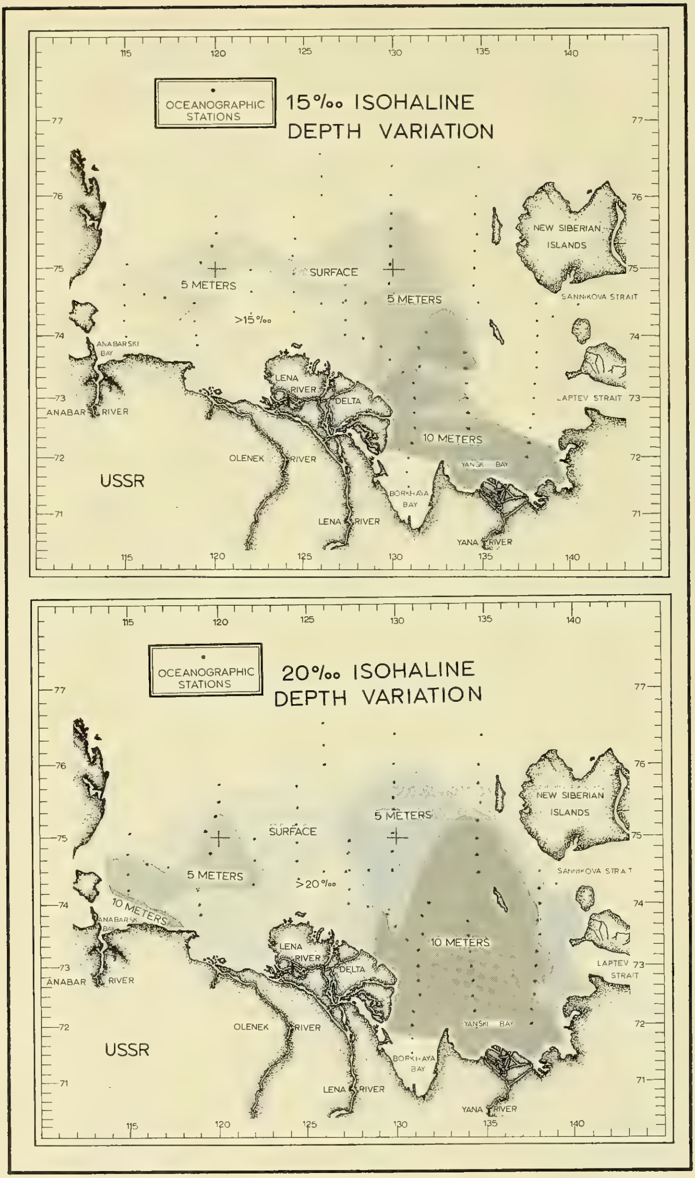


Figure 10. Definition of the Lena River plume at surface, 5, and 10 meter levels using the 15 and 20‰ isohalines.

No direct current measurements were made by NORTHWIND in 1963, and few Russian data are available for the survey area. The existence of a northerly surface current in the eastern Laptev Sea is mentioned briefly, however, by Antonov (1958). Circulation in the Arctic Basin is indicated by Coachman and Barnes (1961) to be north or northeasterly in the region around the New Siberian Islands. Their observations are based primarily upon recorded drift of ice floe stations and vessels as listed in U.S. Navy Hydrographic Office Publication No. 705. Unfortunately, very few additional data seem to be available. Those data available suggest that Arctic Basin circulation and circulation in the Laptev Sea probably influence distribution of low density effluent water, but their importance is difficult to assess without additional data.

Wind observations made aboard NORTHWIND are shown vectorially in figure 11. These data were collected during oceanographic station

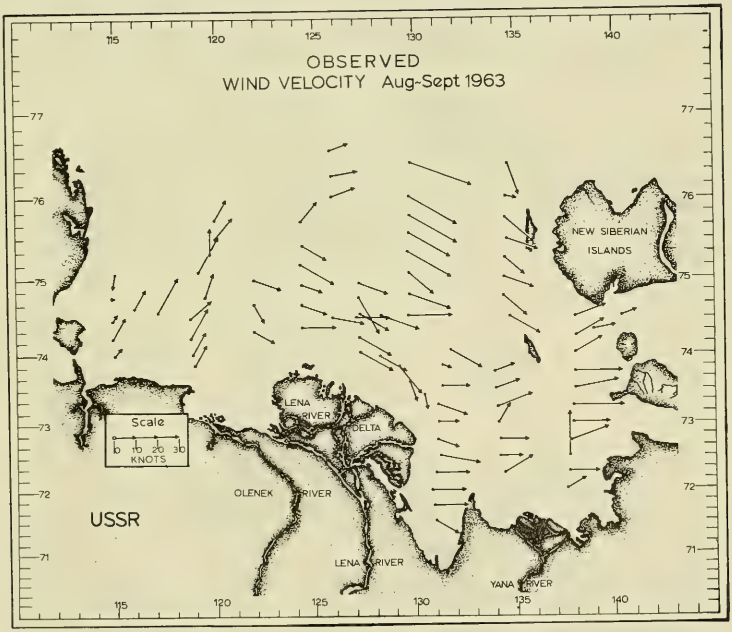


Figure 11. Observed surface wind velocities as noted by NORTHWIND during oceanographic station occupation. Each vector represents a single observation, and a scale is included in the figure.

occupation as near the time of messenger release as possible. Observed wind directions ranged from northeasterly in the southwestern Laptev Sea to easterly and southeasterly in the region of the Lena River plume. Although the wind observations are not synoptic, good correlation appears to exist between these wind directions and the apparent distribution of low density effluent water at the time of the survey.

b. The Khatanga-Anabar Fluvial Plume. Available station coverage and the proximity of the Khatanga and Anabar Rivers necessitate a combined treatment of their runoff effects. No average annual drainage estimates are cited by L'vovich for either river, but drainage area and length for both are listed in table I. The discharge configuration from the two rivers will be termed the Khatanga-Anabar plume, and no attempt will be made to describe individual contributions.

Khatanga-Anabar plume description on the basis of observed temperature and salinity distribution is possible to a lesser extent than in the case of the Lena River. Plume definition based on temperature is limited, but salinity serves to give a first approximation of lateral and vertical plume limits.

(1) Temperature Distribution. Temperature generally did not serve to define the extent of Khatanga-Anabar River water distribution during the NORTHWIND survey in the Laptev Sea. Some suggestion of river effluent distribution can be seen in the interpreted surface -0.5°C isotherm shown in figure 9. Nearly all temperatures observed below the surface in the vicinity of the Anabar River were less than -0.5°C and did not suggest plume delineation.

(2) Salinity Distribution. Surface salinities less than 10 ‰ were noted north of the Anabar River on stations 162 and 167, and salinities less than 20 ‰ were noted on all other stations in the area except station 168. Surface salinity effects

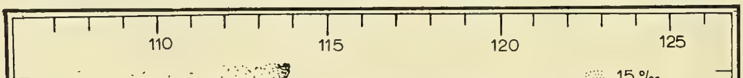


Figure 12. Interpreted distribution of the Khatanga-Anabar fluvial plume as defined by the 15 and 20‰ isohalines at depths of 5 and 10 meters.

from the Khatanga and Anabar Rivers may be seen in figure 10 which shows surface salinity distribution for the southern Laptev Sea.

The Khatanga-Anabar fluvial plume, as defined by the 15 and 20‰ isohalines for depths of 5 and 10 meters, is illustrated in figure 12. Surface indications of river effluent distribution are evident in salinities less than 15‰ but are not shown in this diagram.

c. High Salinity, Low Temperature Water Near The Lena River Delta. Water with higher salinities and lower temperatures than those of ambient water was observed near the surface, approximately 20 miles north of the Lena River Delta, during September 1963. The highest surface salinity noted was 26.38‰ at station 144. Salinity there at 5 meters increased to 32.28‰ . At 15 meters in the same localized region, salinities in excess of 32‰ were observed at stations 174, 176, and 177. Other stations nearby showed consistently lower salinities to a depth of 20 meters. Water with salinities in excess of 33‰ was predominant below 20 meters at all stations occupied in the Laptev Sea.

The lowest surface temperature observed in this region was 0.66°C. At a depth of 5 meters, temperatures of -1.66°, -0.03°, and -0.32°C were observed on stations 144, 176, and 177, respectively. Temperatures colder than -1°C were observed below 15 meters on all stations occupied in the Laptev Sea.

The presence of Arctic Basin Surface Water near the surface in the vicinity of the Lena River Delta is somewhat anomalous since temperatures and salinities in the upper 10 to 15 meters of surrounding water are essentially those of Southern Laptev Water. This suggests the possibility of a relatively localized circulation acting to bring underlying water southward toward the surface.

Coachman and Barnes (1962) point out that estuarine dynamics are developed over the continental slope and in some of the submarine canyons around the Arctic Basin. While the features they discuss involve significantly greater vertical relief, estuarine circulation provides a possible explanation for the temperature and salinity distribution observed north of the Lena River Delta. The existence there of a shallow submarine feature, such as a flooded river channel, could give rise to a circulation which would approach estuarine. A net northerly or northeasterly surface flow over a submarine channel provided by Lena River effluent would tend to advect lower-temperature, higher-salinity water up the channel toward the river delta. In the absence of adequate bathymetric control, it can only be noted that a feature approximately 10 meters deeper than the surrounding bottom was observed in the region discussed.

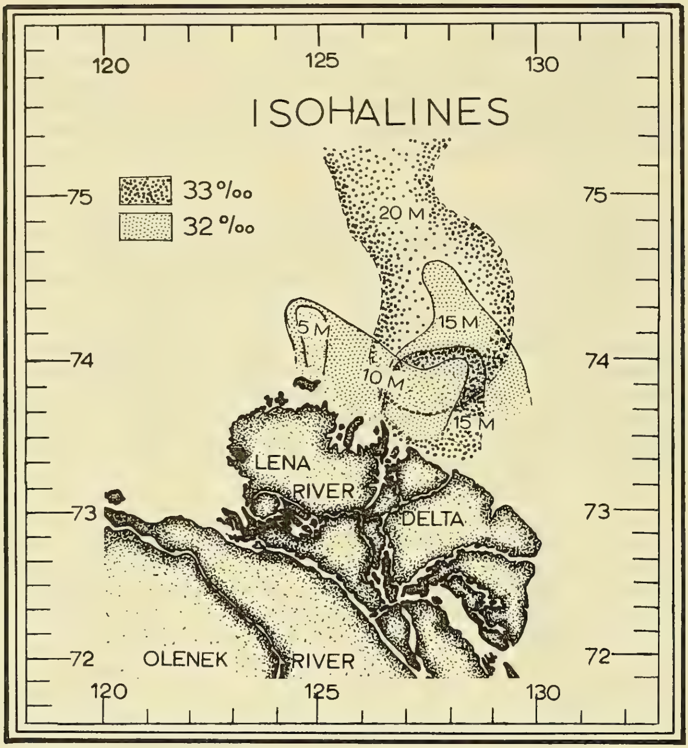


Figure 13. The above diagram illustrates the interpreted distribution of 32 and 33‰ salinity water at depths of 5, 10, 15, and 20 meters.

Figure 13 illustrates the interpreted distribution of the 32 and 33‰ isohalines at depths of 5, 10, 15, and 20 meters. Surface salinities for this region ranged from less than 10 to 26‰ but are not shown, even though they illustrate the same localized distribution. Figure 14 presents three cross-sections drawn from stations occupied in this area.

3. Dissolved Oxygen Distribution. Conditions of dissolved oxygen supersaturation relative to equilibrium sea surface solubility were observed in the Laptev Sea during August and September 1963. Dissolved oxygen values as high as 9.97 ml/l were noted at 12 meters on station 150. Using Carpenter's saturation values, which are corrected to 75 mm total pressure, including water vapor, this figure yields a dissolved oxygen saturation in excess of 115% (Carpenter, 1966).

Oxygen saturation values generally were lower in the vicinity of the Lena River plume, and supersaturation was noted there to a

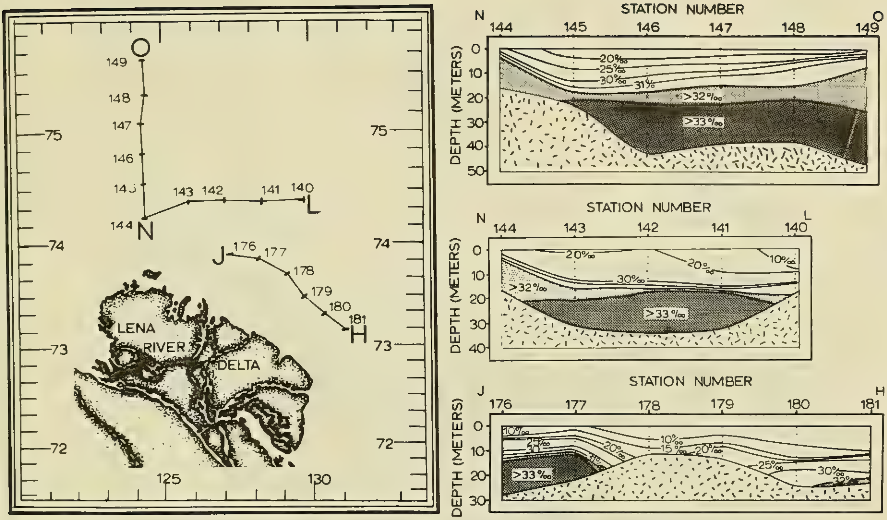


Figure 14. Vertical cross-sections showing salinity distribution drawn from the above lines of stations. Large vertical exaggeration has been used in these cross sections because of the shallow water involved. Station interval is approximately 30 miles.

lesser degree than in the northern and western Laptev Sea. Representative horizontal distribution curves of dissolved oxygen saturation are illustrated in figures 15 and 16 for depths of 5, 10, and 20 meters.

Dissolved oxygen supersaturation observed was primarily limited to the upper 30 meters although it was noted to a depth of 53 meters on station 152.

Anomalously high dissolved oxygen saturation values have been observed previously in the English Channel, the Antarctic, and the Arctic (Harvey, 1960). Oxygen supersaturation in Arctic Surface Water has been reported by Sverdrup and Soule (1933) who recorded saturation values in excess of 110% at several stations occupied on the NAUTILUS expedition.

Oxygen supersaturation generally is attributed to photosynthetic processes since it is observed to occur within the photic zone at depths below effective wind mixing. A recent paper by Williams and Miller (1965) suggests, however, that coverage provided by polar ice combined with cyclic freezing and thawing may lead to anomalous dissolved gas concentrations in the Arctic Basin.

Photosynthesis probably was the most important factor in achieving dissolved oxygen concentrations observed in the Laptev Sea in 1963. Large quantities of greenish-brown biologic material were observed in the water at numerous stations and on ice floes below the water

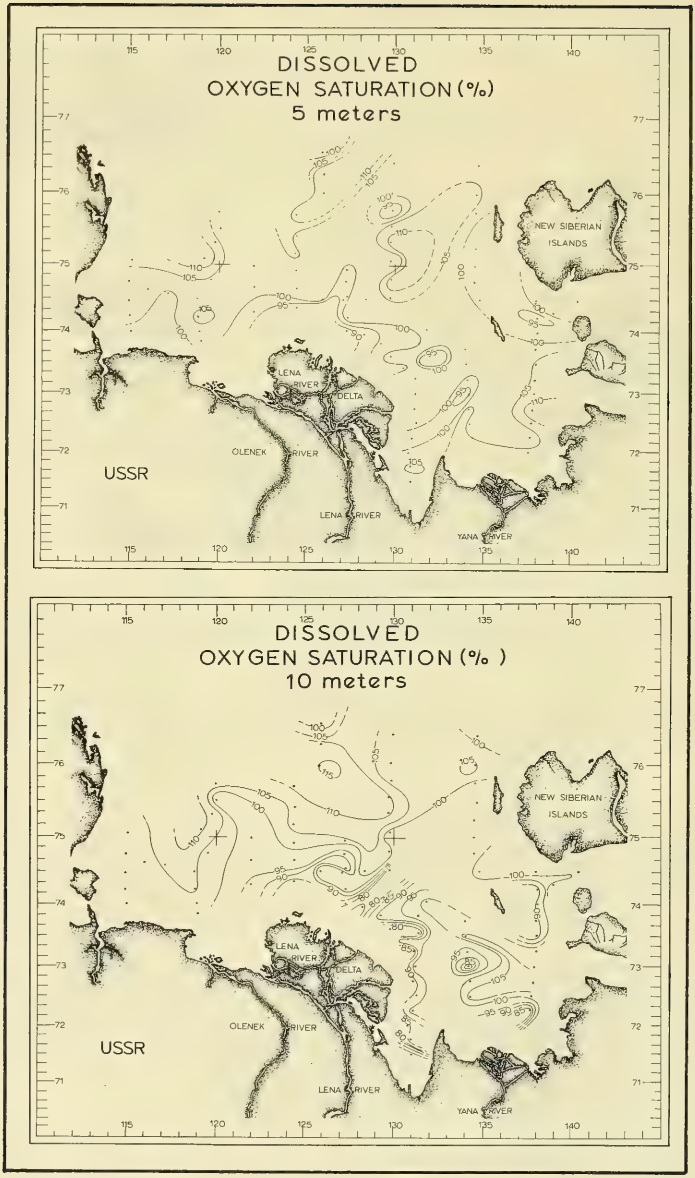


Figure 15. Observed 5 and 10 meter oxygen saturation distribution obtained using data from the 1963 NORTHWIND survey.

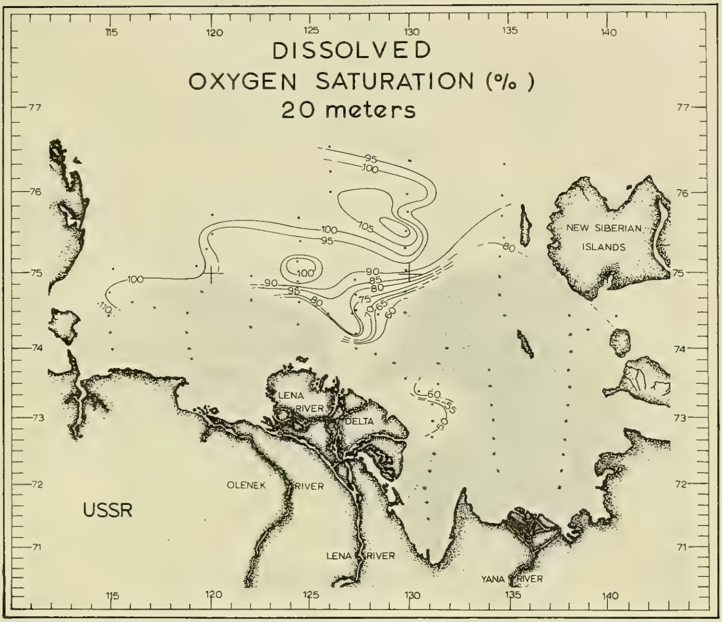


Figure 16. Observed 20 meter oxygen saturation distribution obtained using data from the 1963 NORTHWIND survey. Shaded areas are less than 20 meters deep.

surface. Particulate content was so excessive in sea water samples collected that individual turbidity blanks were required for all photometric determinations.

B. The East Siberian Sea.

The temperature and salinity distributions in the East Siberian Sea, observed by both NORTHWIND and BURTON ISLAND, were highly stratified and similar to those observed in the Laptev Sea in 1963. Temperatures were observed to increase vertically from the bottom and toward the coast, and salinities were observed to decrease vertically from the bottom and toward the coast. Figures 17 and 18 show temperature and salinity profiles drawn from data collected in 1963. Horizontal temperature and salinity distributions as observed in both 1963 and 1964 are shown in figures 19 through 23.

1. Temperature-Salinity Relationships. Water of three temperature-salinity relationships was observed in the East Siberian Sea on both cruises. Very near the Siberian coast, in the region between the Indigirka River and Chaunskaya Bay, temperatures generally above 0°C were observed with salinities less than 20‰ . In the shallower

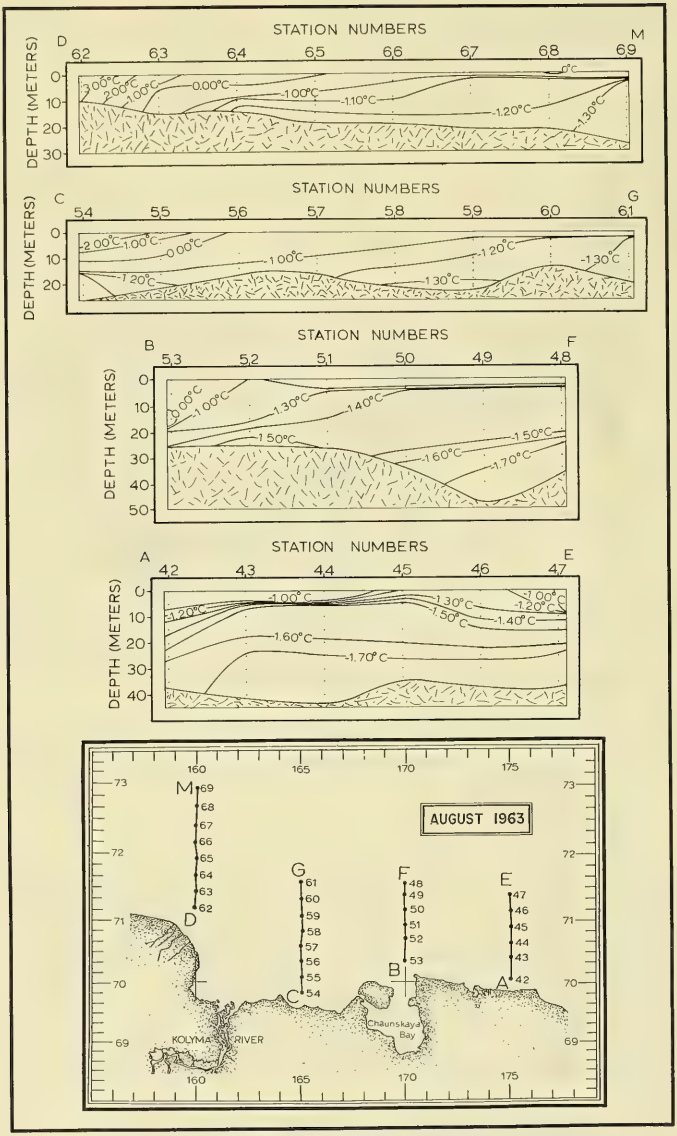


Figure 17. Temperature profiles drawn from data collected by NORTHWIND in 1963. Large vertical exaggerations have been used in these profiles because of the extremely shallow water involved. Note the high degree of stratification.

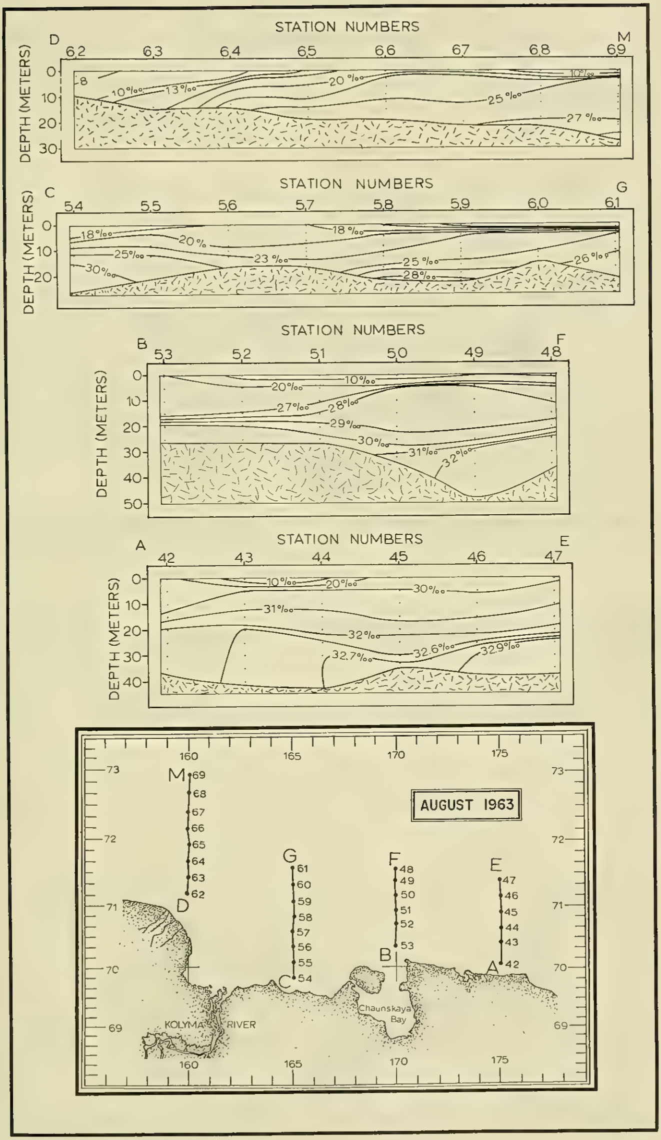


Figure 18. Salinity profiles drawn from data collected by NORTHWIND in 1963. Large vertical exaggerations have been used in these profiles because of the extremely shallow water involved. Note the high degree of stratification.

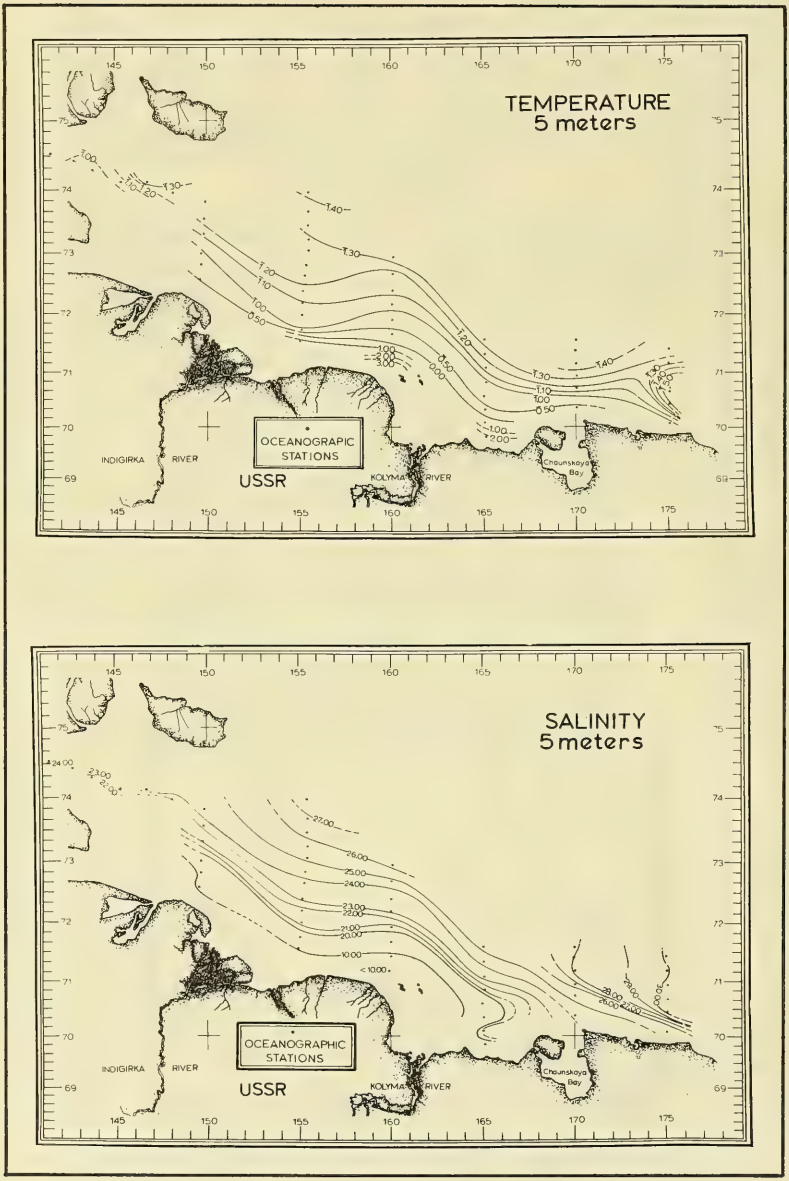


Figure 19. Observed 5 meter temperature and salinity distribution in the East Siberian Sea. All data represented are from the 1963 NORTHWIND survey.

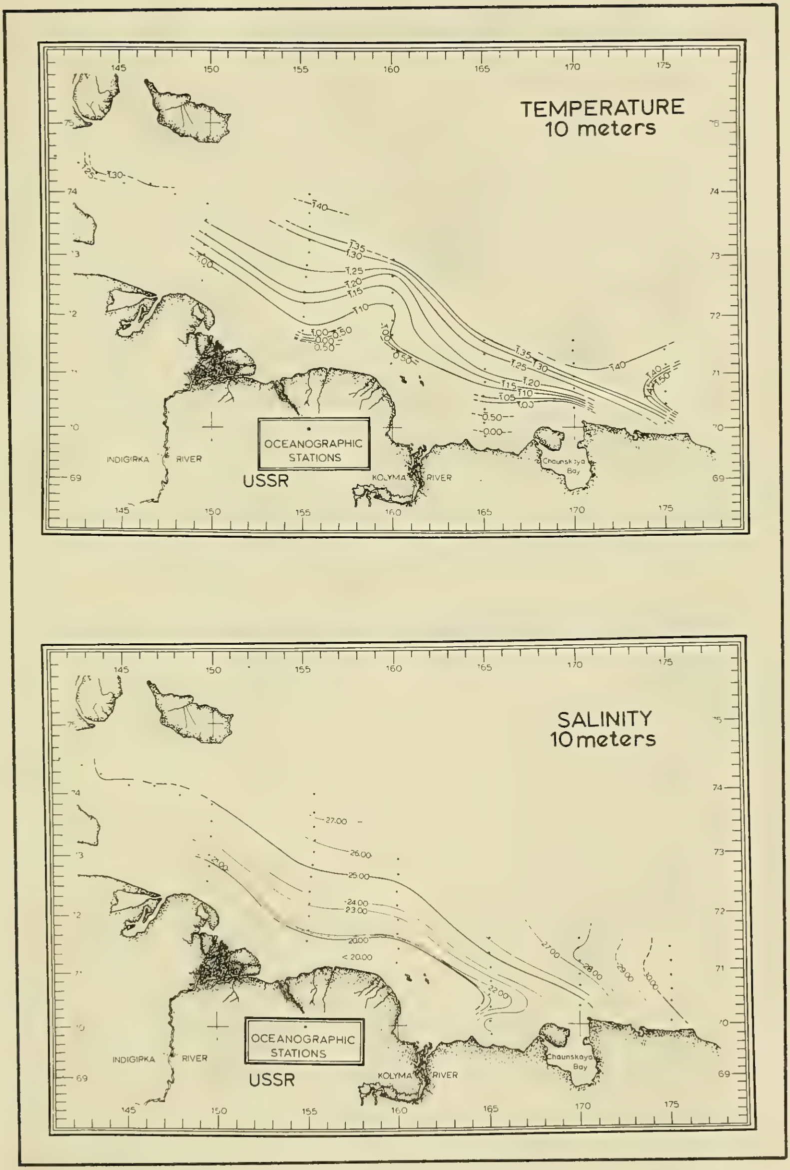


Figure 20. Observed 10 meter temperature and salinity distribution in the East Siberian Sea. All data represented are from the 1963 NORTHWIND survey.

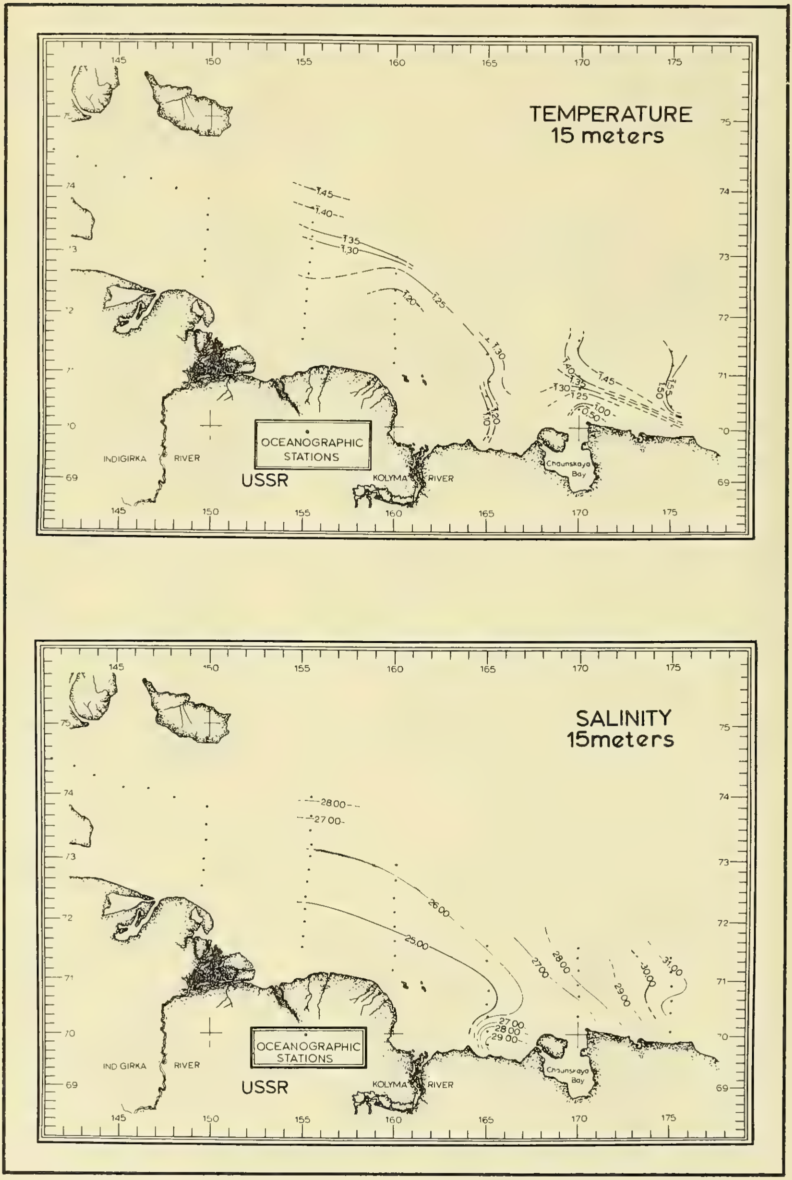


Figure 21. Observed 15 meter temperature and salinity distribution in the East Siberian Sea. All data represented are from the 1963 NORTHWIND survey.

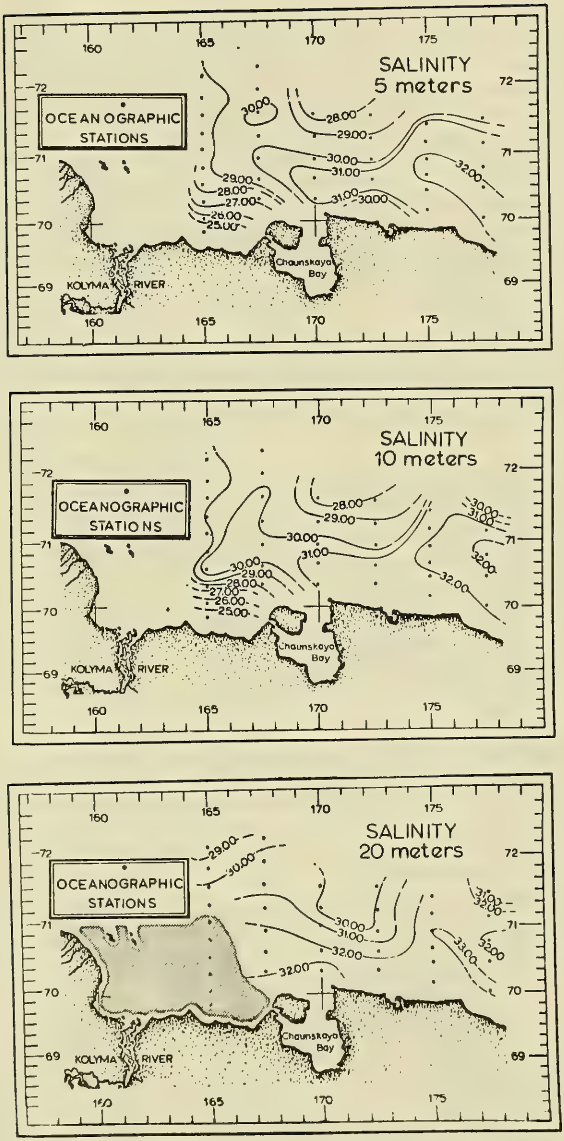


Figure 22. Horizontal salinity distribution at 5, 10, and 20 meters as observed by BURTON ISLAND in 1964. Shaded regions shown are less than 20 meters deep. Stations 18-34 have been omitted here because excessive ship positioning prior to station occupation badly disturbed the shallow water column on these stations.

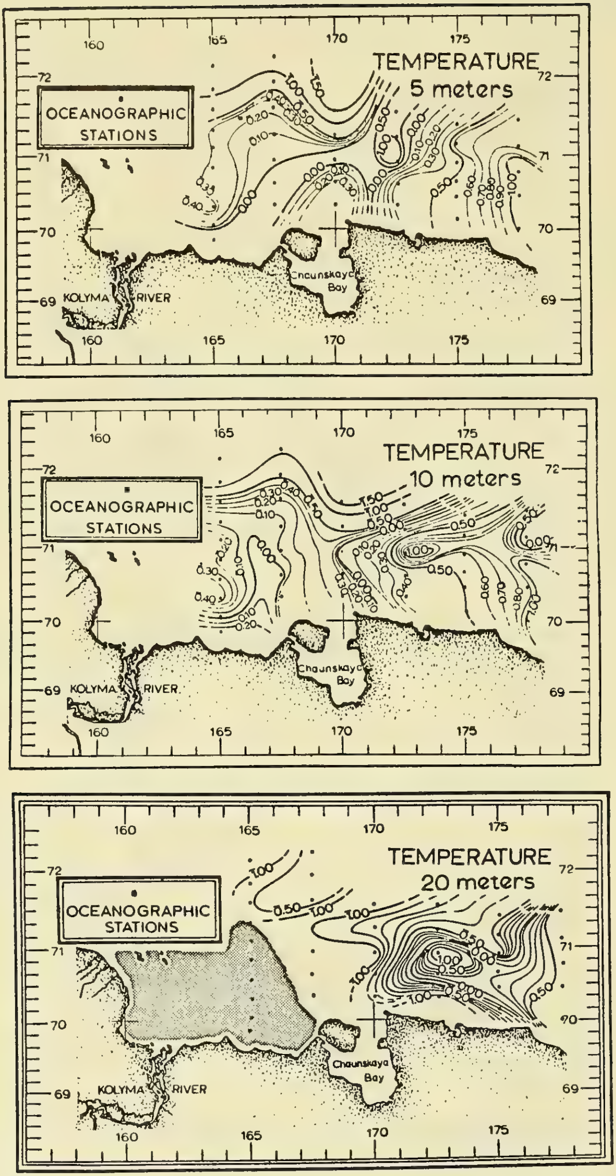


Figure 23. Horizontal temperature distribution at 5, 10, and 20 meters as observed by BURTON ISLAND in 1964. Shaded regions shown are less than 20 meters deep. Stations 18–34 have been omitted here because excessive ship positioning prior to station occupation badly disturbed the shallow water column on these stations.

western portions of the sea, from north of the Kolyma River westward, temperatures from -0.5° to -1.4°C were noted with salinities from 10 to 28‰ . From Chaunskaya Bay eastward through Long Strait and into the Chukchi Sea, temperatures from 1.4° to -1.8°C were observed associated with salinities greater than 28‰.

For descriptive convenience the two water types, water with salinities less than 28‰ and temperatures generally below -0.5°C and water having salinities less than 20‰ and temperatures generally above 0°C, will be termed "Siberian Coastal Water". Water observed in the eastern East Siberian Sea with salinities greater than 28‰ and temperatures from 1.4° to -1.7°C will be termed "Arctic Basin Surface Water" although some of it may originate in the Bering Sea.

a. Siberian Coastal Water. Water described here as "Siberian Coastal Water" is characterized by salinities less than 20‰ . Although two temperature-salinity relationships were observed in this water, both most likely can be attributed to river runoff from the Siberian mainland.

Water in the eastern East Siberian Sea, in the area covered by the NORTHWIND survey, was observed to have salinities less than 28‰ associated with temperatures below -0.5°C. These temperatures and salinities were similar to those observed in Sannikova Strait and the eastern Laptev Sea near the New Siberian Islands. Temperatures observed on the single line of six stations occupied in Sannikova Strait ranged from -0.90° to -1.25°C at the surface and from -1.20° to -1.32°C near the bottom. Salinities observed on the same stations ranged from 21.07 to 24.01‰ at the surface and from 24.82 to 26.02‰ near the bottom.

These low salinities were comparable to those observed in water directly attributable to river drainage, such as that in the southern and eastern Laptev Sea, but the temperatures were somewhat colder. This is not unreasonable since cooling in transit due to mixing and the presence of sea ice is to be expected in this area.

Water near the coast between the Indigirka River and Chaunskaya Bay was observed to have salinities less than 20‰ and temperatures generally above 0°C. These temperatures and salinities can be directly attributed to the addition of river water to this region by the Indigirka and Kolyma Rivers.

Ocean station coverage did not serve to describe the fluvial plume from either the Kolyma or Indigirka River. Eastward from the mouth of the Indigirka River some indication of runoff effects was observed at 5 and 10 meters in offshore isotherm displacement. A similar, though lesser, offshore displacement also was observed in the 5-and 10-meter isohalines shown in figures 19 and 20.

b. Arctic Basin Surface Water. Salinities observed in what has been termed "Arctic Basin Surface Water" were similar to those noted in Arctic Basin Surface Water in the Laptev Sea during 1963, but associated temperatures covered a much broader range during the two summers of observations. Salinities measured in this water during 1963 were greater than 28 ‰ with the exception of some surface values. Very low surface salinities were noted on several stations occupied in Arctic Basin Surface Water, but these probably were caused by local ice melt. A large salinity increase was noted at 5 meters on these stations, and salinity values below 5 meters were always in excess of 28‰ . The highest salinity observed in 1963 was 33‰ at 35 meters at station 47. Salinities observed in Arctic Basin Surface Water in the East Siberian Sea during 1964 were all in excess of 28‰ and ranged as high as 33.15‰ at 28 meters at station 73.

Temperatures observed in this water during August 1963 were below 0°C with values as low as -1.7°C measured near the bottom on several stations. Considerably higher temperatures were measured during September 1964, however, when surface values as high as 1.38°C were noted in the eastern East Siberian Sea. Although most temperatures measured at that time were above 0°C, bottom temperatures as low as -1.64°C also were observed.

Water with salinities in excess of 32‰ was observed at all depths on most of the 41 stations occupied in Long Strait and the Chukchi Sea. Temperatures observed on these stations varied from colder than -1.7°C near the bottom in Long Strait to warmer than 5°C near the surface in Bering Strait. Temperature and salinity distribution observed at 30 meters on these stations is shown in figure 24.

Codispoti (1965) suggests that some of the Pacific Water which flows northward through Bering Strait enters the East Siberian Sea as relatively dense bottom water. Phosphate concentrations which he observed in the East Siberian Sea were similar to those generally found in the North Pacific, yet those he observed in the Laptev Sea were similar to those normally encountered in the North Atlantic. He also noted that phosphate-nitrate relationships in the Bering and Chukchi Seas were similar to the ones observed in the East Siberian Sea but were markedly different from those in the Laptev Sea. Upon examining several possible mechanisms for increasing East Siberian Sea water phosphate concentrations over those in the Laptev Sea, he concludes that the most likely method would be through mixing with water from the North Pacific.

2. Dissolved Oxygen Distribution. Dissolved oxygen supersaturation relative to equilibrium sea-surface oxygen solubility was observed in the East Siberian Sea during the summers of 1963 and 1964. Dissolved oxygen values noted during 1964 were somewhat lower than those observed in 1963, and supersaturation did not appear as prevalent.

Dissolved oxygen values measured during 1963 in the eastern regions of the East Siberian Sea were somewhat higher than those observed in the Laptev Sea a few weeks later. The highest content measured was 12.64 ml/l at 5 meters on station 44. Using Carpenter's saturation values this figure yields a saturation in excess of 147%; however, most other saturation values calculated for the same region were under 130%, as shown in figures 24 and 25.

The highest dissolved oxygen value measured in the East Siberian Sea during the 1964 BURTON ISLAND cruise was at 20 meters on station 65. At this station, an oxygen concentration of 9.55 ml/l or slightly in excess of 113% saturation was noted.

In 1963, saturation values generally increased seaward from the Siberian mainland and toward the eastern regions of the East Siberian Sea. No clear relationship was observed between the relatively low-salinity, high-temperature water from the Indigirka and Kolyma Rivers and dissolved oxygen distribution during either year. This may be partly attributable to the station interval employed.

Supersaturation observed in 1963 was limited entirely to the upper 25 meters in the eastern East Siberian Sea and primarily to the upper 15 meters in the sea's shallower western regions. The water column above these depths was supersaturated at most stations occupied.

Supersaturation noted in 1964 also was observed entirely above 25 meters, but it appeared discontinuous from the surface to that depth. Slightly supersaturated water was noted on many stations at depths between 4 and 23 meters with undersaturated water above and below. This water sometimes occurred only at a single observed depth within this interval, but more frequently it appeared at several consecutive depths.

Observed dissolved oxygen supersaturation most likely can be attributed to photosynthesis. Greenish-brown biologic material was observed in the water and on ice floes in the East Siberian Sea during 1963 and 1964 similar to that noted in the Laptev Sea. Excessive particulate content was evident in sea water samples collected at all depths. A biological relationship is further suggested by the discontinuous nature of the dissolved oxygen supersaturation observed in 1964.

Sverdrup, in 1922, noted oxygen supersaturation in the East Siberian Sea and attributed the phenomenon to phytoplankton assimilation processes. He observed a marked decrease in supersaturation between the years 1922 and 1923 and suggested that heavy ice cover in 1923 served to limit biologic productivity (Sverdrup, 1929). Probably this was also a factor in the decrease in supersaturation observed between 1963 and 1964 since ice cover was extensive in the East Siberian Sea during 1964.

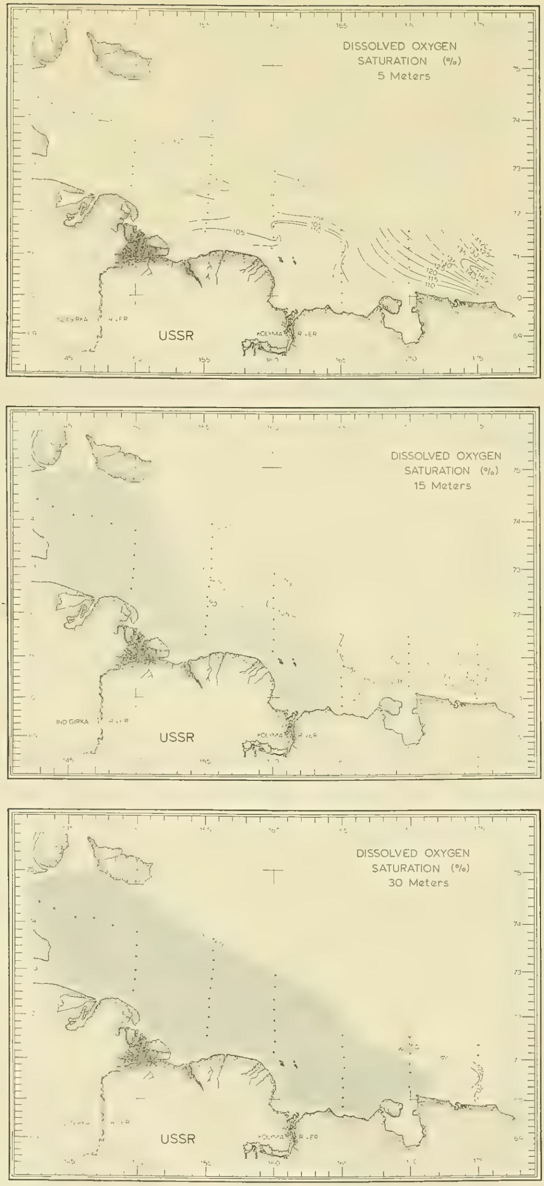


Figure 24. Dissolved oxygen saturation distribution at 5, 15, and 30 meters obtained using data from the 1963 NORTHWIND survey. Shaded areas denote depths less than that indicated in the figures.

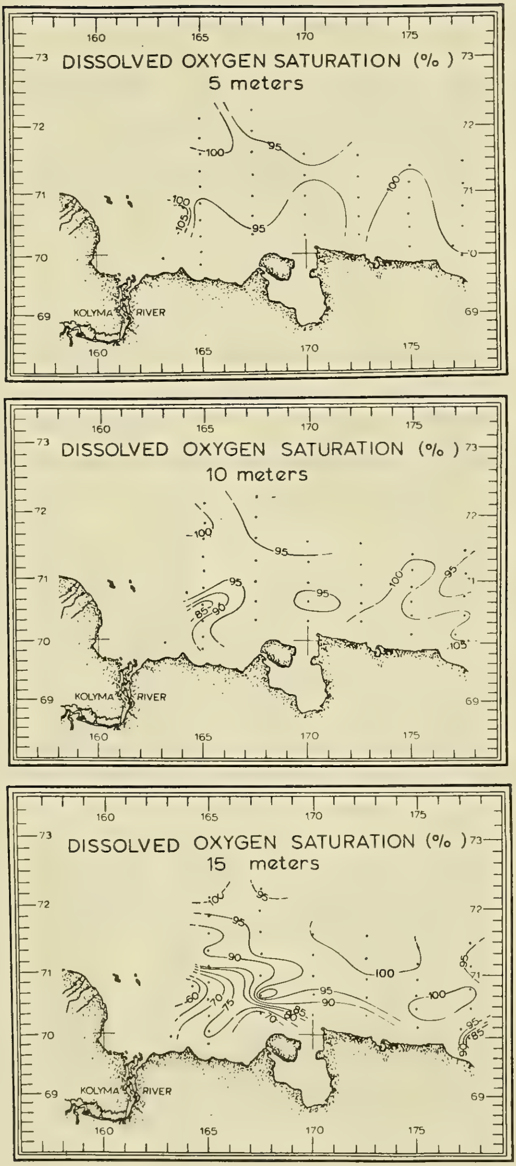


Figure 25. Dissolved oxygen saturation distribution at 5, 10, and 15 meters obtained using data from the 1964 BURTON ISLAND survey.

3. Anchor Station Data. Three anchor stations varying from 25 to 44 hours duration were occupied in the East Siberian Sea in 1964. During these stations, periodic Nansen casts and current observations were made when ice conditions permitted. Anchor station locations are shown in figure 26.

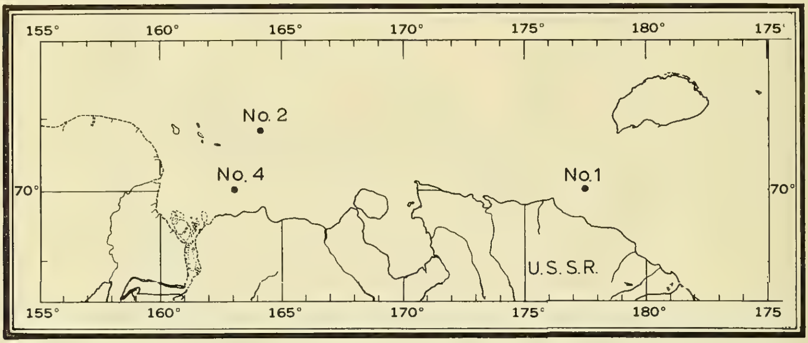


Figure 26. Anchor stations occupied by BURTON ISLAND. Station 3 is not shown because it is near Bering Strait and lies outside the area covered by this report.

a. Nansen Casts. A total of 20 Nansen casts was taken on the 3 anchor stations. The first two stations of six Nansen casts each were occupied in mid-July, and the third of eight Nansen casts was occupied in mid-September. Time between casts varied from 4 to 9 hours, and bottles were spaced every two meters throughout the shallow water column.

Casts 1 through 6 at anchor station 1 showed a surface temperature variation of 0.86°C and a surface salinity variation of 6.25 ‰ over a 25-hour period. Similar variations occurred at all depths sampled, but they generally decreased in magnitude with depth.

Casts 7 through 12 at anchor station 2 showed a surface temperature variation of 1.30°C and a surface salinity variation of 1.53‰ for a similar 25-hour period (Fig. 27). Temperature variation generally decreased with depth as in Nansen casts 1 through 6, but salinity variation increased slightly below 10 meters.

Casts 35 through 42 at anchor station 4 showed a surface temperature variation of 0.67°C and a surface salinity variation of 5.45 ‰ over a period of 42 hours (Fig. 28). Both temperature and salinity variations generally decreased below 10 meters. Above 10 meters, there was a marked salinity increase on Nansen casts 40 and 41. The sharpest increase occurred at 6 meters where salinity increased 7.31 ‰ from cast 41 to 42. A similar, though lesser, increase occurred at all depths sampled down to 8 meters. On cast 42, salinities from the surface to 8 meters varied by only 0.06 ‰

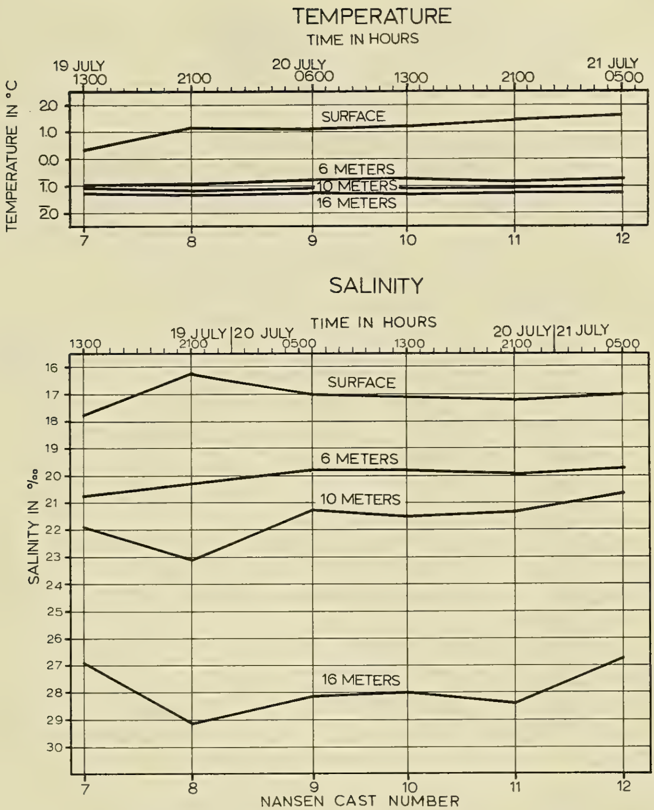


Figure 27. Temperature and salinity variations versus time in hours for anchor station 2. Similar variations were observed on anchor stations 1 and 3 but are not shown.

as opposed to earlier variations of over 8.0‰ in the same depth interval. The increase in surface salinity and the resulting salinity uniformity in the upper 8 meters were attributed to wind mixing of relatively low salinity surface water with higher salinity water from below.

Observed winds for the period were from a nearly constant direction of 240° to 270° True and a nearly constant speed of 6 m/sec until cast 40 when a wind speed of 14 m/sec was observed; by station 42, winds were as high as 18 m/sec.

Clearly defined periodicity is not immediately evident in temperature and salinity variations observed on the three anchor stations occupied. If tidal effects were present at these stations

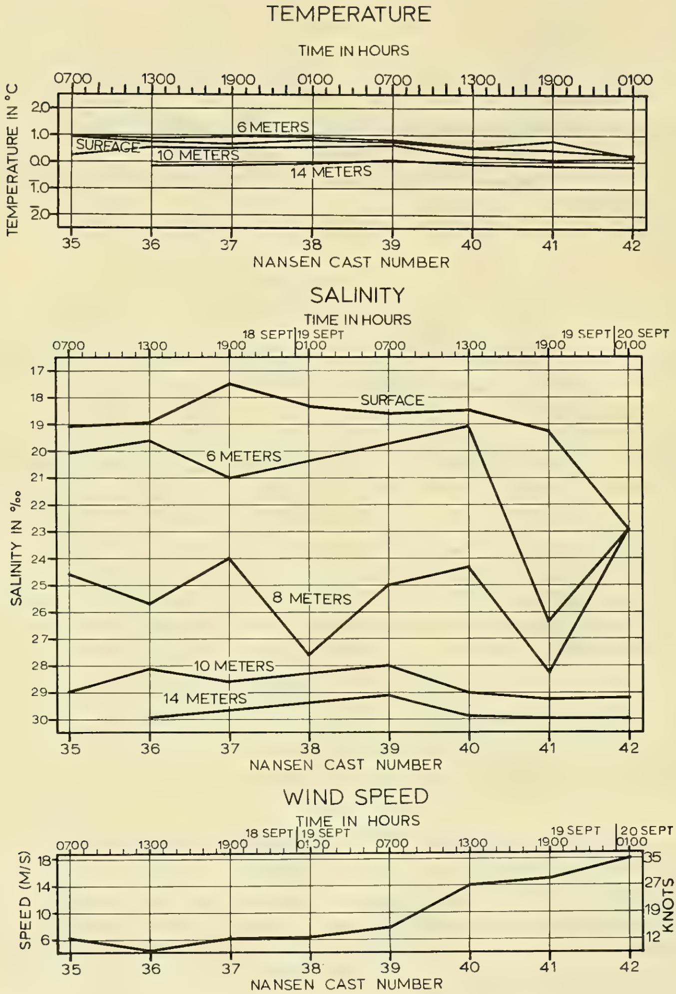


Figure 28. Temperature and salinity variations versus time in hours for anchor station 4. A plot of wind speed versus time is also included. Note the effects of increased wind speed on observed temperature and salinity in the upper eight meters on casts 41 and 42.

they appear to have been obscured by local factors such as wind mixing, ice melt, or the influx of river runoff.

Sustained winds of 18 m/sec for a 12-hour period were effective in achieving near isohaline conditions down to 8 meters on station 42 during mid-September 1964. Wind mixing below 8 meters was not evident during station occupation.

b. Current Observations. Current observations were made at all three anchor stations in the East Siberian Sea in 1964 (Fig. 29). Current speed was obtained from Gemware, Ekman, and Hydro Products meters, but current direction could be obtained only with the Gemware meters.

When possible, current observations were attempted every 30 minutes during station occupation. Representative coverage necessitated changes in observation depths to accommodate changes in bathymetry from station to station.

In evaluating the current data, an attempt was made to disregard any considered questionable. Resulting data discussed here represent approximately 60% of the total collected during the BURTON ISLAND survey. Although current speeds of .5 cm/sec were recorded, these are unreliable since they are below the generally accepted lower threshold velocity of 3 cm/sec for the Savonius rotor used in the Hydro Products meter and the impellors used in the Gemware and Ekman meters. These measurements most likely represent speeds too low to be accurately measured with the equipment employed, and they will be designated here simply as less than 3 cm/sec.

The seven observations made on station 1 in Long Strait suggested that surface flow set in an easterly-southeasterly direction and that bottom flow set in a west-northwesterly direction. Measured surface current speed was less than 3 cm/sec, but this is thought to be inaccurate because of the ship's inability to hold anchor. Actual surface current speed was probably similar to that recorded at 12 meters, which ranged from 3 to 20 cm/sec. Flow set east-southeasterly both at the surface and 12 meters. Near the bottom at 25 meters, flow set to the northwest with speeds from 5 to 20 cm/sec.

At the time of the survey near 71°00'N, 164°00'E, the 17 observations made on station 2 also suggested that flow set east-southeasterly both at the surface and at 12 meters and set in a northwesterly direction near the bottom. Measured surface current speeds ranged from 5 to 25 cm/sec setting primarily to the southeast. Observations at 9 meters indicated flow to set in a more southerly

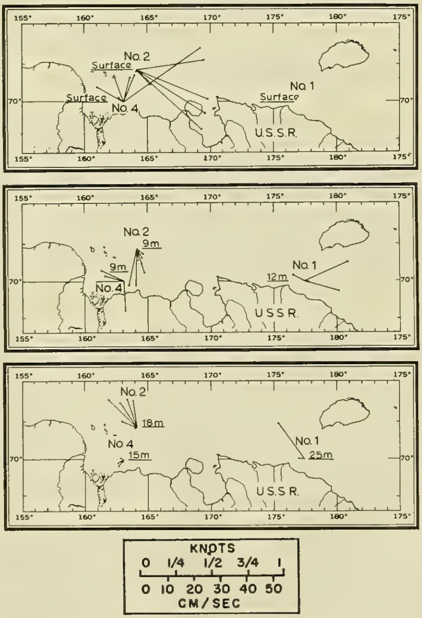


Figure 29. Observed currents are shown vectorially for anchor stations 1, 2, and 4. Current observation depths varied from station to station but the depth at which the observation was made is indicated near its representative vector. Each vector represents a single current measurement.

direction with speeds from 5 to 15 cm/sec. Near the bottom at 18 meters, flow was to the northeast with speeds similar to those at 9 meters.

Near the mouth of the Kolyma River at anchor station 4, the 14 observations made suggested flow to set in a northerly direction at the surface and in a southwesterly direction near the bottom. Measured surface current speeds ranged from 5 to 30 cm/sec. At 9 meters, current speeds from 5 to 20 cm/sec were measured setting to the west.

Figure 29 illustrates vector representations of observed currents at stations 1, 2, and 4. Each vector represents a single observation. Figure 30 illustrates observed currents versus time at stations 2 and 4.

Because of data collection limitations and the paucity of observations, current data discussed here are probably at best considered questionable. The general current directions, however, appear to corroborate the circulation patterns suggested by observed temperature and salinity distribution.

V. DISCUSSION AND CONCLUSIONS

A. Interpretive Limitations.

Although much information has been forthcoming, oceanographic studies in the shallow Siberian seas are subject to some basic limitations, as pointed out previously by Aagaard (1964) and Codispoti (1965). Dynamic equilibrium probably is poorly developed or absent in both the East Siberian and Laptev Seas. Reflecting the absence of steady state conditions, wide variations in temperature and salinity were frequently observed from one station to the next during both the 1963 NORTHWIND and 1964 BURTON ISLAND surveys.

Few direct current observations are available for either the East Siberian Sea or Laptev Sea. No current observations were made during the 1963 NORTHWIND survey, and current observations were made at only four anchor stations during the BURTON ISLAND survey. Dynamic computations, ordinarily used when direct current observations are unavailable, are of dubious value in these shallow seas. No suitable reference level for such computations exists in a water column typically less than 100 meters deep.

Bathymetric data available are inadequate and detailed charts can not be constructed for either sea. Since circulation in these seas is probably subject to bathymetric influence, lack of such knowledge hampers oceanographic interpretation.

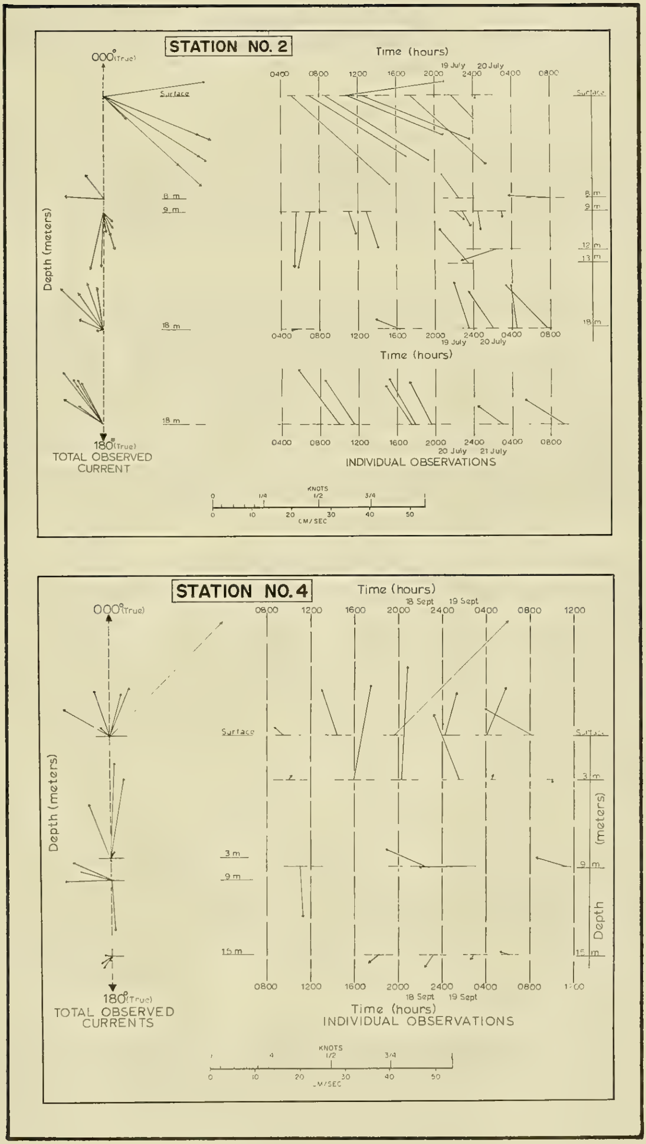


Figure 30. Current data collected on stations 2 and 4. Total observed currents are shown vectorially to the left and observed current versus time in hours is shown vectorially to the right. Observations were repeated on 20 and 21 July for the 18 meter depth on station 4 and both results are shown. Each vector represents a single current measurement.

In spite of these limitations, oceanographic interpretations presented here probably are valid because they concern quasi-permanent, large-scale oceanographic features.

B. The Laptev Sea.

Temperatures and salinities observed in the Laptev Sea during the NORTHWIND survey revealed a high degree of stratification, with temperatures increasing vertically from the bottom and toward the Siberian coast and salinities decreasing vertically from the bottom and toward the coast.

Water characterized by two general temperature-salinity relationships was observed during August and September 1963. Water in the northern Laptev and that below 20 meters on most oceanographic stations had salinities from 28.5 to 33.5 ‰ and temperatures from -1.5 to -1.8°C. Water near the surface in the southern Laptev Sea showed a broader range of higher temperatures and lower salinities than that in the north. Observed temperatures ranged from 0° to over 3°C and observed salinities ranged from slightly over 2 to 28 ‰. These relatively high temperatures and low salinities are attributable to effluent from the five large rivers that empty into the Laptev Sea.

Distribution of Lena River effluent was best evident in 1963 on the basis of observed salinity distribution although it also was apparent in observed temperature distribution. The Lena River fluvial plume, as defined on the basis of both temperature and salinity, appeared to extend in a north to northeasterly direction from the river delta. Lateral plume extent in the Laptev Sea was limited almost entirely to the region between the Lena River Delta and the New Siberian Islands.

Vertical distribution of the low-salinity, high-temperature water was limited to the upper 15 meters in the form of a rough wedge.

Offshore circulation and prevailing winds probably are effective in governing distribution of effluent water in the Laptev Sea, but their relative importance is unclear. Available current information is insufficient to permit adequate evaluation of current effects, but good correlation was noted between surface wind directions observed during oceanographic station occupation and the apparent distribution of low density effluent water.

The extent of Khatanga and Anabar River runoff was evident primarily in observed salinity distribution. The combined fluvial plume from the two rivers, as indicated by salinity distribution, extended in a northeasterly direction from the Khatanga River Estuary at the time of the survey. Vertical distribution of this low-salinity water appeared limited to the upper 10 meters.

The presence of what appears to be a localized estuarine circulation north of the Lena River Delta may be caused by the existence there of a shallow submarine feature.

Conditions of dissolved oxygen supersaturation were observed in the Laptev Sea during August and September 1963. At that time, lower dissolved oxygen values were observed in Lena River effluent than in water in the northern and western Laptev Sea, which was frequently supersaturated. Dissolved oxygen supersaturation usually was observed in the upper 30 meters, but on one station it was observed as deep as 53 meters.

High observed dissolved oxygen values most likely can be attributed to photosynthesis.

C. The East Siberian Sea.

The temperature and salinity distributions observed in the East Siberian Sea by NORTHWIND and BURTON ISLAND were highly stratified, similar to those observed in the Laptev Sea. Temperatures were noted to increase vertically from the bottom and toward the Siberian coast, and salinities were noted to decrease vertically from the bottom and toward the coast.

Water of three temperature-salinity relationships was observed in both 1963 and 1964. Near the coast between the Indigirka River and Chaunskaya Bay, temperatures above 0°C were noted with salinities below 20 ‰. In the sea's shallower western regions, temperatures from -0.5 to -1.4°C were observed with salinities from 10 to 28‰ . Both of these temperature-salinity relationships most likely can be attributed to river runoff, with cooling and mixing in transit accounting for the colder temperatures and slightly higher salinities. Since this water was observed near the coast, it has been termed "Siberian Coastal Water". Water in the eastern East Siberian Sea through Long Strait and into the Chukchi Sea was observed to have temperatures from 1.4° to -1.8°C associated with salinities from 28.0 to 33.1 ‰. Because these temperature and salinity characteristics are similar to those in the Eurasian Arctic Basin, this water has been termed "Arctic Basin Surface Water" although some of it probably originates in the Bering Sea.

In the East Siberian Sea in 1964, three anchor stations were occupied, and Nansen casts and current observations were made. Temperature and salinity measurements showed changes in surface temperature as great as 1.30°C and changes in salinity as great as 6.25 ‰ over a 25-hour period. Similar, though generally smaller, variations were noted at all depths sampled.

Sustained winds of 18 m/sec for a 12-hour period were effective in achieving near isohaline conditions down to 8 meters on anchor station 4.

Clearly defined periodicity was not evident in observed temperature and salinity variations.

Seven current observations made at anchor station 1 suggest an easterly-southeasterly surface flow of less than 3 to 20 cm/sec in Long Strait at the time of the survey. A west-northwesterly flow of 5 to 20 cm/sec was observed near the bottom.

Seventeen observations made on anchor station 2 also suggest an easterly-southeasterly flow of 5 to 25 cm/sec at the surface and a northwesterly flow of 5 to 15 cm/sec near the bottom.

Fourteen observations made on anchor station 4 suggest a northerly surface flow of 5 to 30 cm/sec near the mouth of the Kolyma River. Near the bottom at 15 meters, a southwesterly flow of less than 5 cm/sec was observed.

Dissolved oxygen supersaturation relative to equilibrium sea surface oxygen solubility was observed in the East Siberian Sea during the summers of 1963 and 1964. Observed dissolved oxygen values generally increased seaward from the Siberian mainland and toward the eastern regions of the sea in 1963. Supersaturation usually was limited to the upper 25 meters in the eastern East Siberian Sea and the upper 15 meters in the sea's shallower western regions.

Observed supersaturation most likely can be attributed to photosynthesis, as was the case in the Laptev Sea.

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APPENDIX

CONVERSION TABLES

CONVERSION OF DEGREES CELSIUS TO DEGREES FAHRENHEIT

°C	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
-2	28.40	28.22	28.04	27.86	27.68	27.50	27.32	27.14	26.96	26.78
-1	30.20	30.02	29.84	29.66	29.48	29.30	29.12	28.94	28.76	28.58
-0	32.00	31.82	31.64	31.46	31.28	31.10	30.92	30.74	30.56	30.38
0	32.00	32.18	32.36	32.54	32.72	32.90	33.08	33.26	33.44	33.62
1	33.80	33.98	34.16	34.34	34.52	34.70	34.88	35.06	35.24	35.42
2	35.60	35.78	35.96	36.14	36.32	36.50	36.68	36.86	37.04	37.22
3	37.40	37.58	37.76	37.94	38.12	38.30	38.48	38.66	38.84	39.02
4	39.20	39.38	39.56	39.74	39.92	40.10	40.28	40.46	40.64	40.82
5	41.00	41.18	41.36	41.54	41.72	41.90	42.08	42.26	42.44	42.62

CONVERSION OF METERS TO FEET

METERS	0	1	2	3	4	5	6	7	8	9
0	0.0	3.3	6.6	9.8	13.1	16.4	19.7	23.0	26.2	29.5
10	32.8	36.1	39.4	42.7	45.9	49.2	52.5	55.8	59.1	62.3
20	65.6	68.9	72.2	75.5	78.7	82.0	85.3	88.6	91.9	95.1
30	98.4	101.7	105.0	108.3	111.5	114.8	118.1	121.4	124.7	128.0
40	131.2	134.5	137.8	141.1	144.4	147.6	150.9	154.2	157.5	160.8
50	164.0	167.3	170.6	173.9	177.2	180.4	183.7	187.0	190.3	193.6
60	196.8	200.1	203.4	206.7	210.0	213.3	216.5	219.8	223.1	226.4
70	229.7	232.9	236.2	239.5	242.8	246.1	249.3	252.6	255.9	259.2
80	262.5	265.7	269.0	272.3	275.6	278.9	282.2	285.4	288.7	292.0
90	295.3	298.6	301.8	305.1	308.4	311.7	315.0	318.2	321.5	324.8
100	328.1	331.4	334.6	337.9	341.2	344.5	347.8	351.0	354.3	357.6

CONVERSION OF KNOTS TO CENTIMETERS PER SECOND

KNOTS	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	0.0	5.1	10.3	15.4	20.6	25.7	30.9	36.0	41.2	46.3
1	51.5	56.6	61.8	66.9	72.1	77.2	82.4	87.5	92.7	97.8
2	103.0	108.1	113.3	118.4	123.5	128.7	133.8	139.0	144.1	149.3
3	154.4	159.6	164.7	169.9	175.0	180.2	185.3	190.5	195.6	200.8
4	205.9	211.1	216.2	221.4	226.5	231.7	236.8	242.0	247.1	252.2
5	257.4	262.5	267.7	272.8	278.0	283.1	288.3	293.4	298.6	303.7
6	308.9	314.0	319.2	324.3	329.5	334.6	339.8	344.9	350.1	355.2
7	360.4	365.5	370.6	375.8	380.9	386.1	391.2	396.4	401.5	406.7
8	411.8	417.0	422.1	427.3	432.4	437.6	442.7	447.9	453.0	458.2
9	463.3	468.5	473.6	478.8	483.9	489.1	494.2	499.3	504.5	509.6

CONVERSION OF KNOTS TO METERS PER SECOND

KNOTS	0	1	2	3	4	5	6	7	8	9
00	0	0.5	1.0	1.5	2.1	2.6	3.1	3.6	4.1	4.6
10	5.2	5.7	6.2	6.7	7.2	7.7	8.2	8.8	9.3	9.8
20	10.3	10.8	11.3	11.8	12.4	12.9	13.4	13.9	14.4	14.9
30	15.4	16.0	16.5	17.0	17,5	18.0	18.5	19.1	19.6	20.1
40	20.6	21.1	21.6	22.1	22.7	23.2	23.7	24.2	24.7	25.2
50	25.7	26.3	26.8	27.3	27.8	28.3	28.8	29.3	29.9	30.4
60	30.9	31.4	31.9	32.4	33.0	33.5	34.0	34.5	35.0	35.5
70	36.0	36.6	37.1	37.6	38.1	38.6	39.1	39.6	40.2	40.7
80	41.2	41.7	42.2	42.7	43.2	43.8	44.3	44.8	45.3	45.9
90	46.3	46.9	47.4	47.9	48.4	48.9	49.4	49.9	50.5	51.0

U.S. Naval Oceanographic Office
SOME SUMMER OCEANOGRAPHIC FEATURES OF THE LAPTEV AND EAST SIBERIAN SEAS, 52 p., including 31 figs., 1 table. (TR-200)

This report deals with some summer oceanographic features of the Laptev and East Siberian Seas. Emphasis is placed on the effects on the water characteristics by the effluent of the rivers emptying into these seas. Analyses of data obtained from two NAVOCEANO surveys performed in 1963 and 1964 are presented.

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4. Ships-USCGC NORTHWIND (W-AGB 282)
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12. SPONSORING MILITARY ACTIVITY

U.S. Naval Oceanographic Office

13. ABSTRACT

In August-September 1963, a high degree of stratification for both temperature and salinity was observed in the Laptev and East Siberian Seas. Temperatures decreased with depth and with distance away from the Siberian coast, and salinities decreased vertically from the bottom and toward the coast.

The five large rivers emptying into the Laptev Sea influence the temperature-salinity characteristics to a great extent causing high temperatures and low salinities near the coast and in the upper layers seaward. The Lena River fluvial plume, on the basis of salinity distribution, was observed to extend in a north to northeasterly direction from the river delta. The combined effects of the Khatanga and Anabar River runoff extended in a northeasterly direction from the Khatanga River Estuary with vertical distribution of the low salinity water limited to the upper 10 meters.

Water of three temperature-salinity relationships was observed in the East Siberian Sea in both 1963 and 1964. Near the coast, between the Indigirka River and Chaunskaya Bay, warm low salinity water was observed. In the sea's shallower western regions, cold water with slightly higher salinities was noted. Both of these water types can be attributed to river runoff with cooling and mixing in transit accounting for the colder water and higher salinities. Water in the eastern East Siberian Sea through Long Strait and into the Chukchi Sea was observed to have water as cold as -1.8°C and as warm as 1.4°C associated with salinities from 28 to 33‰.

Lower dissolved oxygen values were present in Lena River effluent than in water in the northern and western Laptev Sea. In the East Siberian Sea, dissolved oxygen values generally increased seaward and toward the sea's eastern regions.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Oceanography						
Arctic Oceanography						
Laptev Sea						
East Siberian Sea						
USCGC NORTHWIND (W-AGB 282)						
USS BURTON ISLAND (AGB 1)						

PRELIMINARY REPORT

21 Jan 1965

1964 ARCTIC SURVEY - USS BURTON ISLAND

The U. S. Naval Oceanographic Office conducted a general investigative study of the East Siberian Sea during the summer of 1964. The oceanographic survey assignment on board the USS BURTON ISLAND (AGB-1) was completed during the period 1 July through 10 October.

Initially, the proposed survey plans called for work in the East Siberian, Laptev, Barents and Kara Seas, but , due to heavy ice conditions and a change in operational commitments it became necessary to concentrate efforts almost entirely in the East Siberian Sea.

The study area is bounded by 155° east longitude on the west and Wrangell Island on the east. The northernmost stations were at approximately 74° 30'N latitude, but the majority of stations occupied were below 73°N latitude.

Areal coverage was attempted using a net of 55 oceanographic stations and three 25-hour current stations. Nineteen additional oceanographic casts were taken during the occupation of the current stations, bringing the total to 74 in the East Siberian Sea.

Serial oceanographic data were collected using Nansen reversing water bottles. Salinity, dissolved oxygen and nitrogen, inorganic phosphate, pH and turbidity fractions were drawn and analyzed for each depth sampled.

Encl: (1) to NAVOCEANO ltr Code 3520/KRN-ncf, ser 4804

Salinities were determined using an inductively coupled salinometer. Dissolved oxygen samples were analyzed using the NAVOCEANO modification of the Swinnerton-Linnenbom-Cheek gas chromatographic method. A total of 324 titrations were run for evaluation of the gas chromatographic equipment using the Thompson and Robinson modification of the Winkler method for dissolved oxygen determination. Inorganic soluble phosphate was determined by the Strickland and Parsons spectrophotometric method and pH was determined using an expanded scale pH meter. A Helige turbidimeter was employed for determining turbidity. All analyses were conducted aboard ship.

Frozen samples were collected at every bottle depth on 74 casts for nitrate and silicate analyses in the NAVOCEANO laboratory. Forty-eight samples of sea water also were collected on four stations for deuterium analysis at the Woods Hole Oceanographic Institute.

Fifty-five bottom sediment samples were collected, 35 of which were gravity cores and 20 of which were orange peel grabs. The gravity cores were taken using a six foot long, two inch diameter coring device with 200 pounds of weight attached. Grab samples were obtained using an orange peel grab with a canvas covering to minimize sampling washing.

An additional current station of 25 hours duration also was occupied in Bering Straits while enroute to the survey area. While on this station a time series suite of six Nansen casts was accomplished.

Survey accomplishments are tabulated in Table 1. Station locations are depicted on Figures 1 and 2.

TABLE 1

SUMMARY OF OBSERVATIONS, BURTON ISLAND, 1964

Type of Observation or Sample	Recipient	Number
Ocean Stations	NAVOCEANO	83
Serial Temperature	NAVOCEANO	884
Serial Salinity	NAVOCEANO	884
Serial Dissolved O_2/N_2	NAVOCEANO	880
Serial Inorganic PO_4	NAVOCEANO	884
Serial pH	NAVOCEANO	131
Serial Bottom Samples	U. of Wash.	55
Serial Deuterium Samples	WHOI	84
Winkler Oxygen Determinations	NAVOCEANO	324
Turbidities	NRL	639

FIGURE I STATIONS OCCUPIED BY U.S.S. BURTON ISLAND (AGB-I) EAST SIBERIAN SEA — JULY-SEPTEMBER, 1964

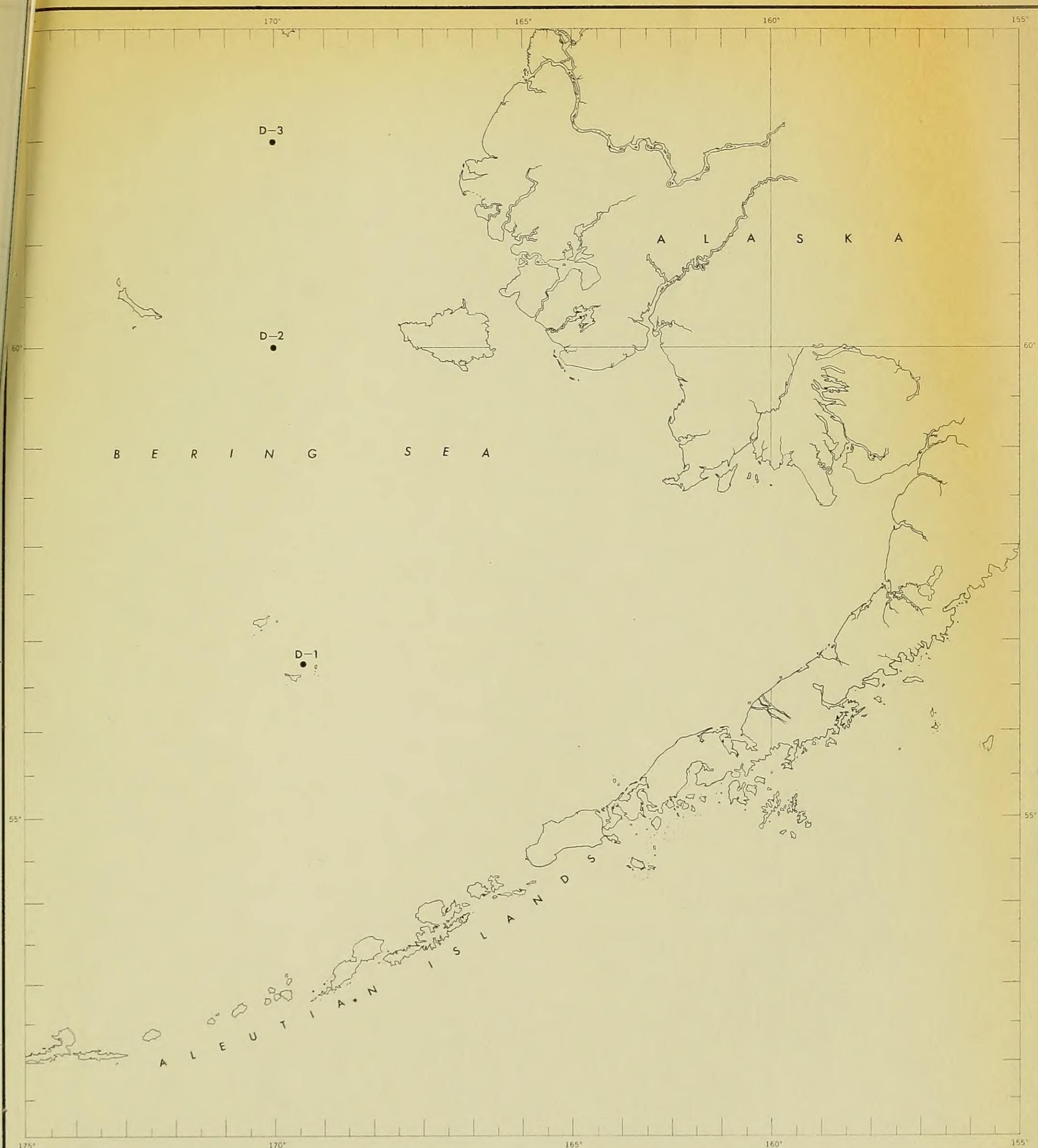

FIGURE 2 STATIONS OCCUPIED BY U.S.S. BURTON ISLAND (AGB-1) BERING SEA—AUGUST 1964